



Collocated AIRS and CERES clear-sky observations: quantify reanalysis biases and assess long-term stability

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in collaboration with Norman Loeb, Seiji Kato, Mike Bosilovich,
et al. (CERES-GEOS 5 eval group)

2019 CERES Spring Science Team Meeting
May 9th, 2019

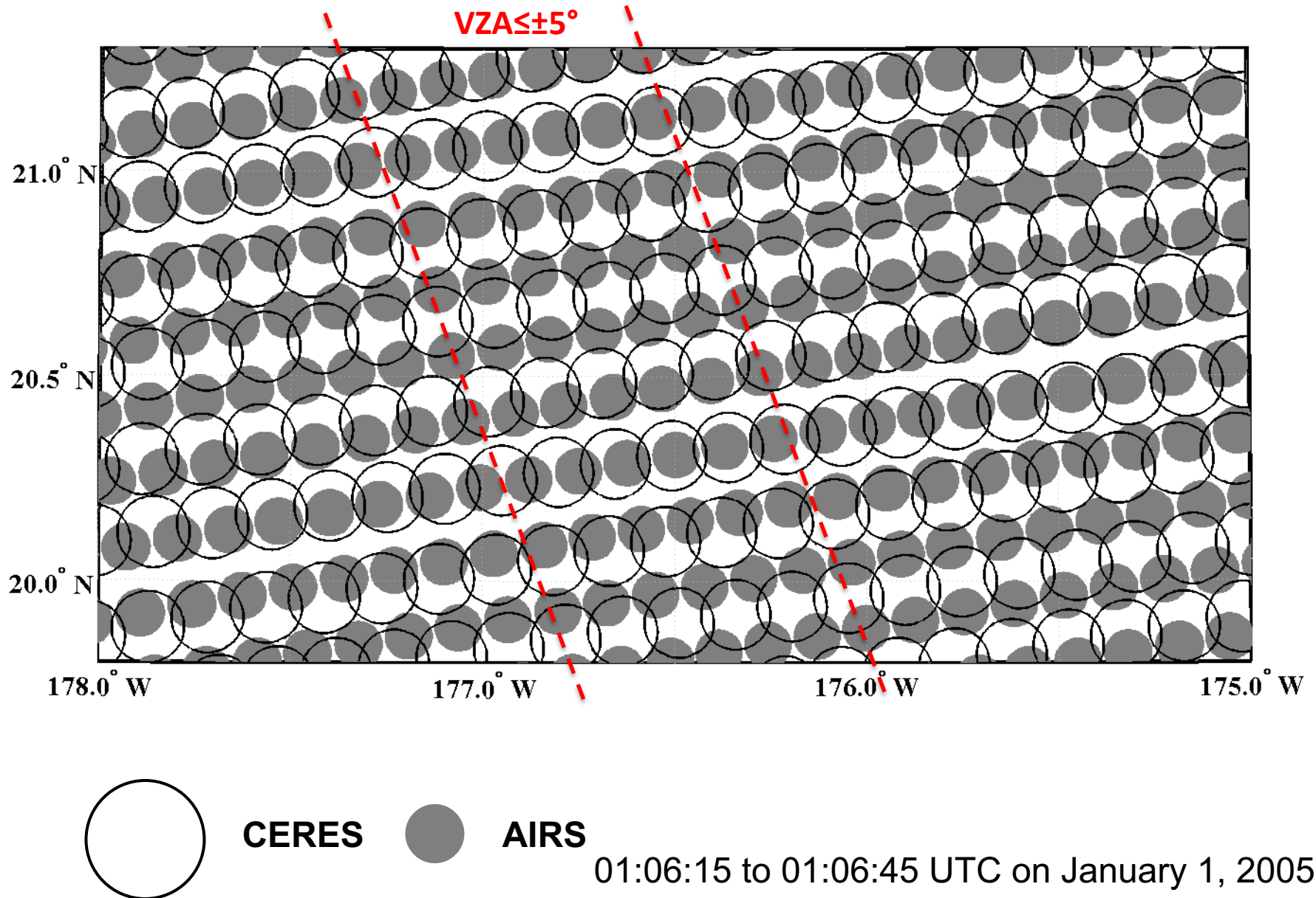
Acknowledgements: NASA CERES project



Basic facts and thinking

- AIRS radiometric calibration and stability are excellent
- AIRS L1 data
 - 2378 channels
 - 19.6 billions of spectra so far
- Good co-location between AIRS and CERES on Aqua
- How to make better use of such synergy to serve the objectives of CERES Science Team?

In this talk, I will

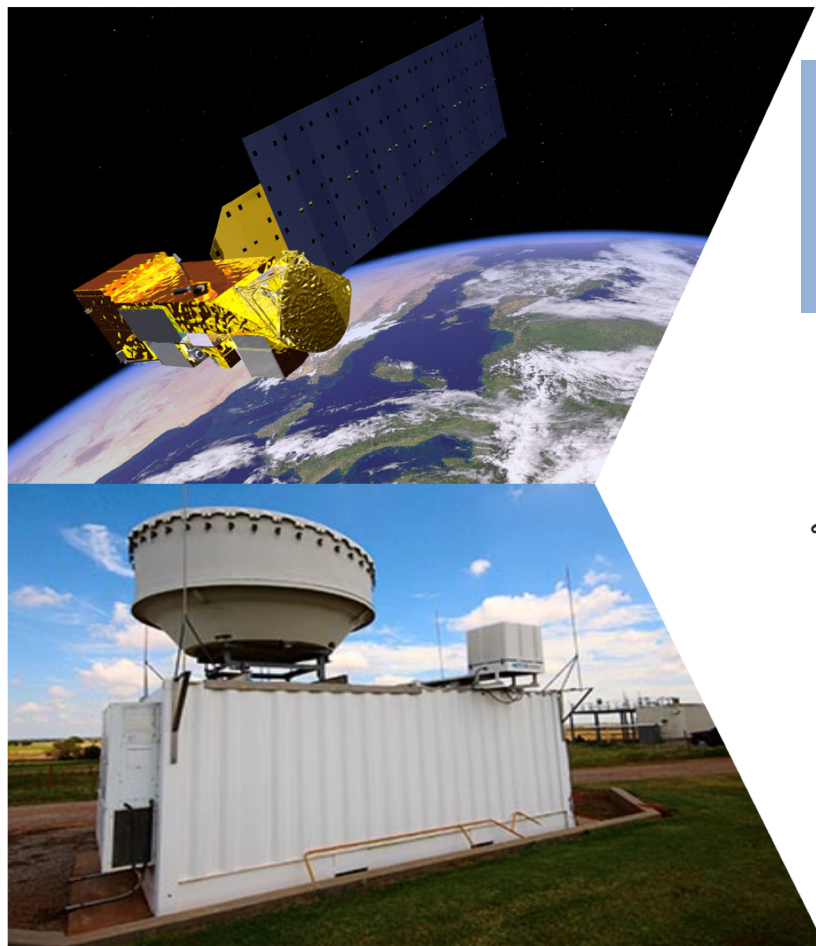




In this talk, I will

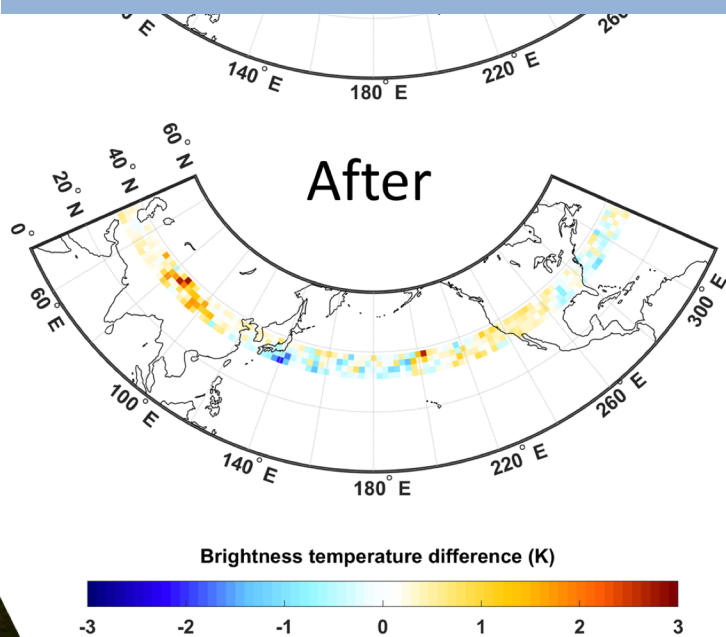
- use a very small subset of AIRS data
 - Collocated with CERES **clear-sky** footprints
 - VZA within $\pm 5^\circ$ (nadir view)
- to explore two topics
 - Estimate biases in reanalysis (T, q) fields
 - Same can be applied to GEOS-5 operational analysis
 - Estimate the long-term consistency between AIRS radiance and CERES unfiltered LW radiance

Reanalysis bias quantification: spectral radiance closure



Before

- Very limited data to use
- Cannot derive time-dependent bias
- Applicability to other climate zones












RESEARCH ARTICLE

10.1029/2018JD028850

Key Points:

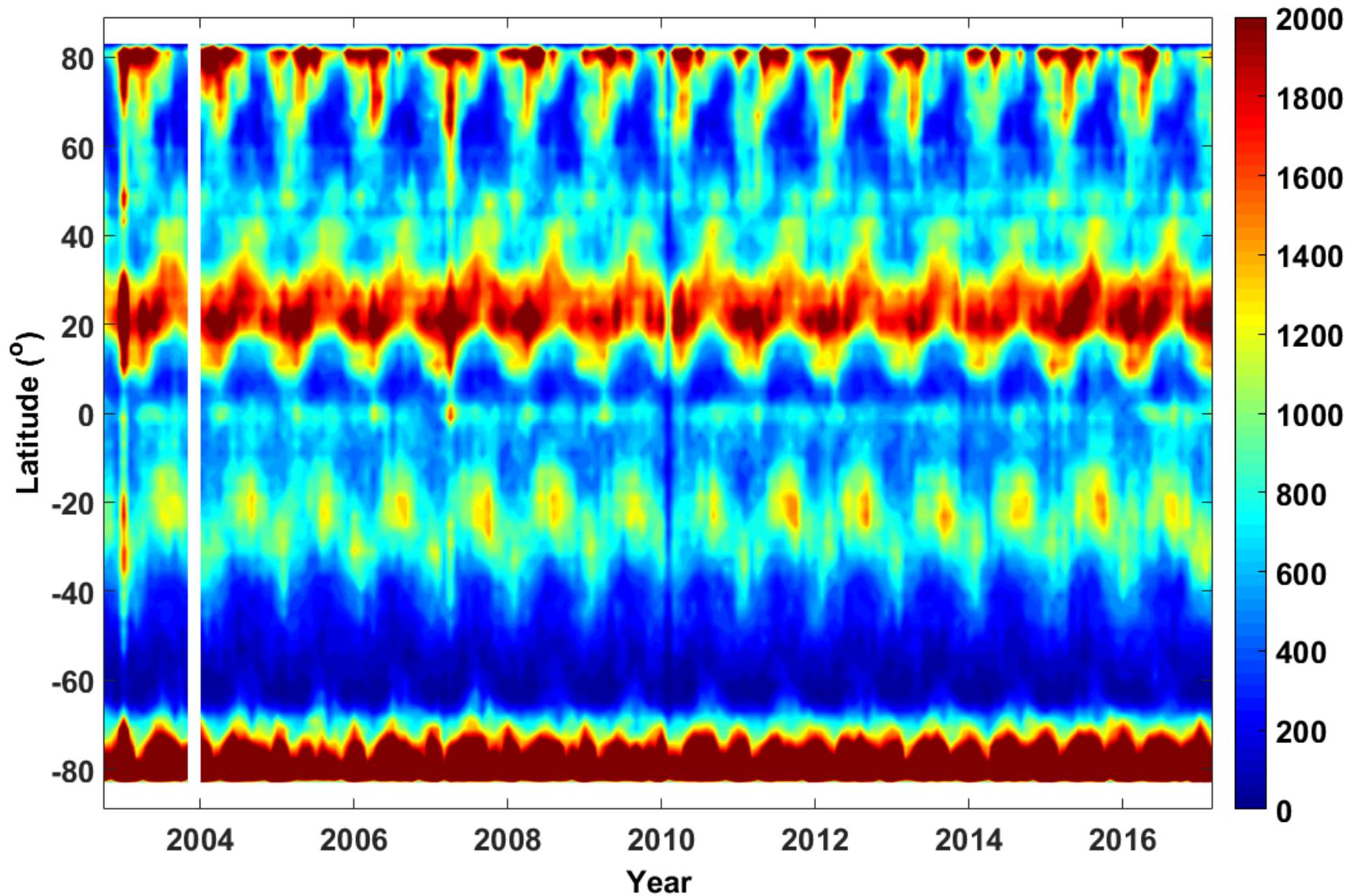
- ERA Interim and MERRA-2 reanalyses in terms of spectral radiances are evaluated
- Both reanalyses have a wet bias in

Using AIRS and ARM SGP Clear-Sky Observations to Evaluate Meteorological Reanalyses: A Hyperspectral Radiance Closure Approach

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of collocated clear-sky AIRS and CERES-Ed4 footprints (VZA < $\pm 5^\circ$)



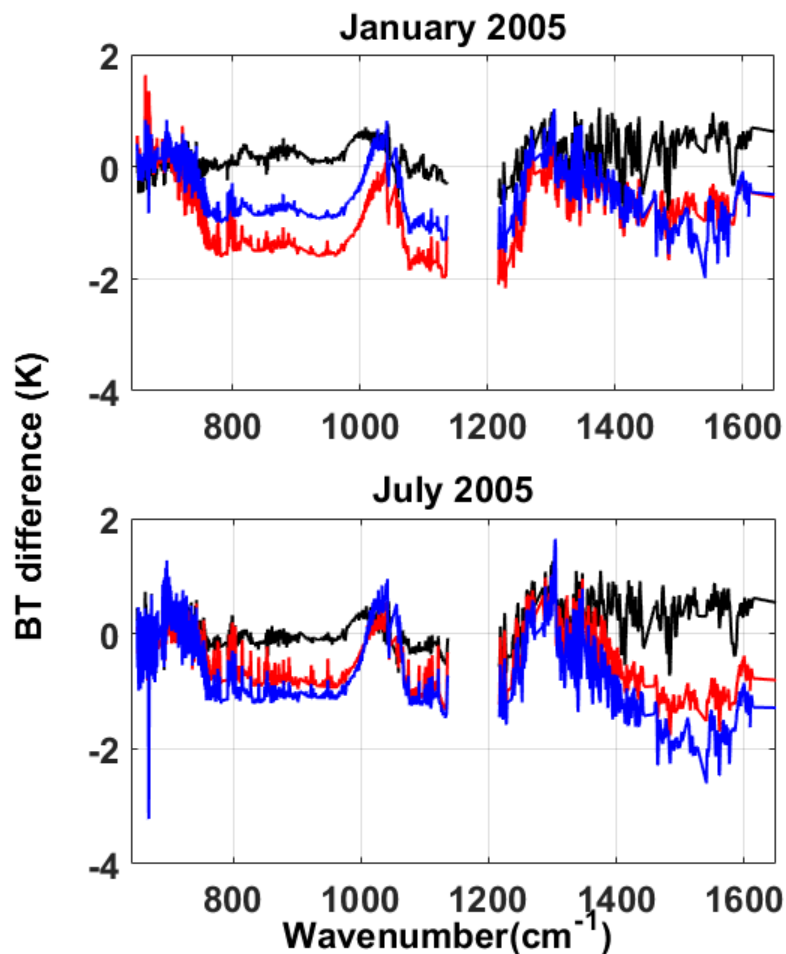
2-lat by 1-month bins, Sep. 2002 – Feb. 2017

Approaches

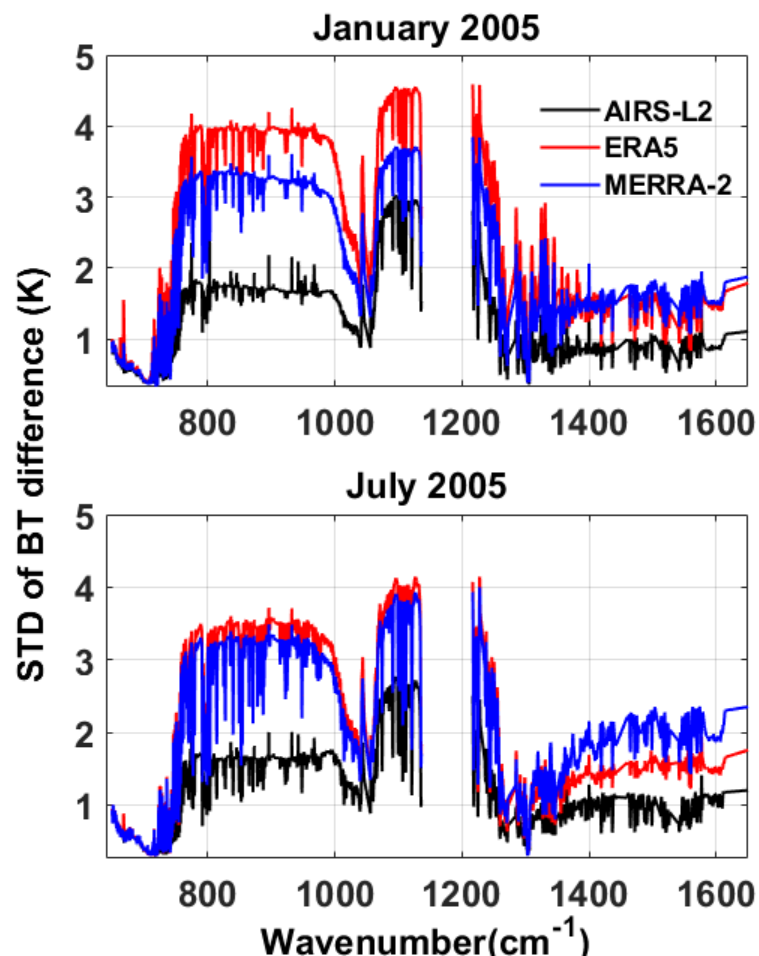
- Use the PCRTM to generate synthetic AIRS radiances from reanalyses as well as AIRS L2
 - MERRA-2, ERA-5, ERA-I
- Use exhaustive grid-search method to obtain fractional correction needed to minimize the BT(v) difference
 - In three layers, 200-400 hPa, 400-600 hPa, and 600-800 hPa
- Details in Chen et al. (2018; JGR)

An example for 30-40N
(3784 spectra in Jan. 2005 and 5898 spectra in July 2005)

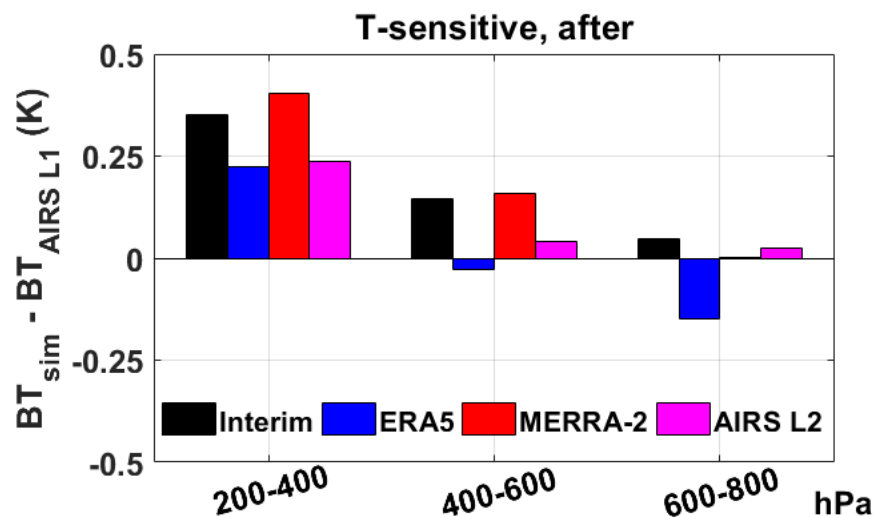
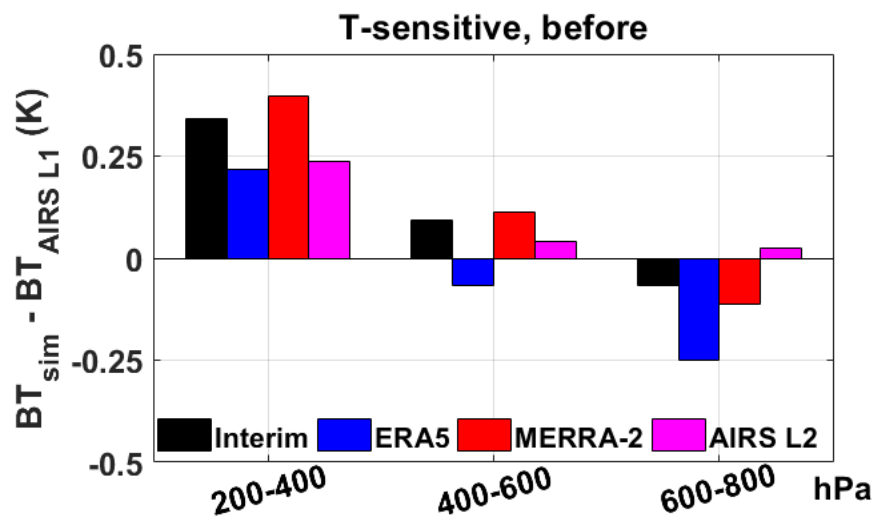
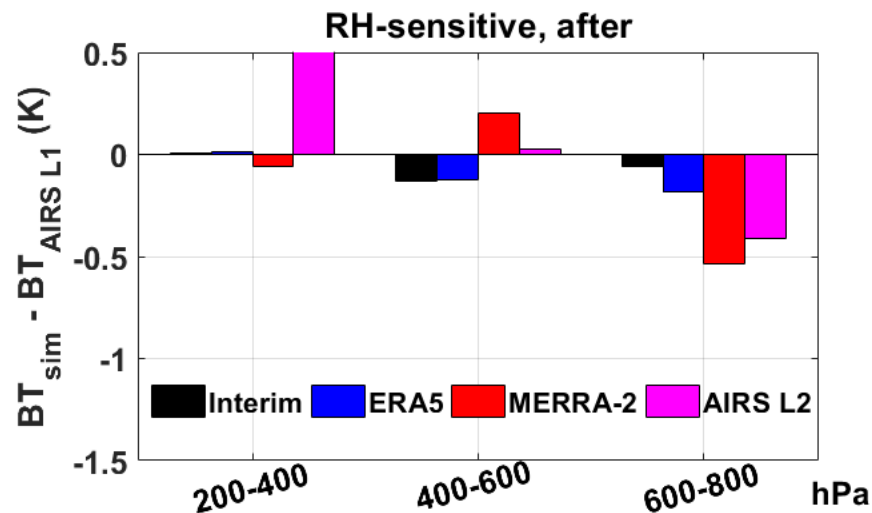
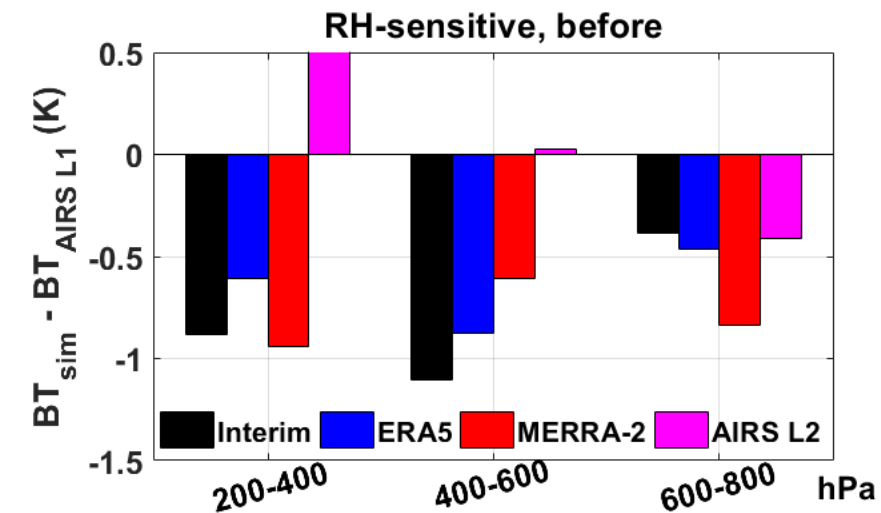
Mean



Standard deviation



BT difference before and after correction for water vapor profiles in Jan. 2005 (30-40N)



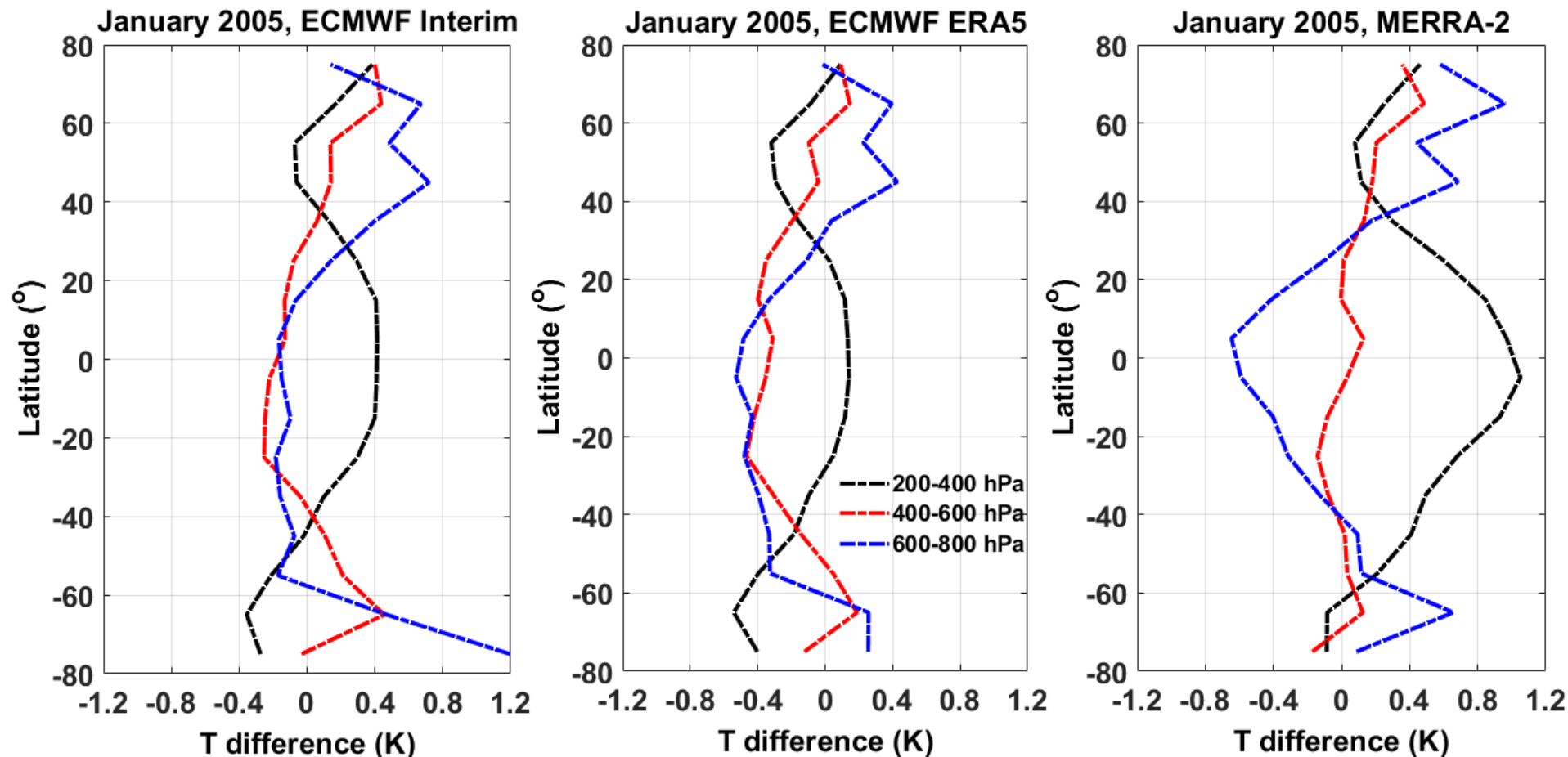
	ERA-I	ERA5	MERRA-2
200-400 hPa	-15.6%	-11.4%	-15.9%
400-600 hPa	-15.1%	-12.7%	-10.2%
600-800 hPa	-8.9%	-9.2%	-13.0%



Examine the robustness of such bias estimation

- Geographical dependence
- Composition analysis
 - With respect to TPW and T_s
- Still using January 2005 as the case study

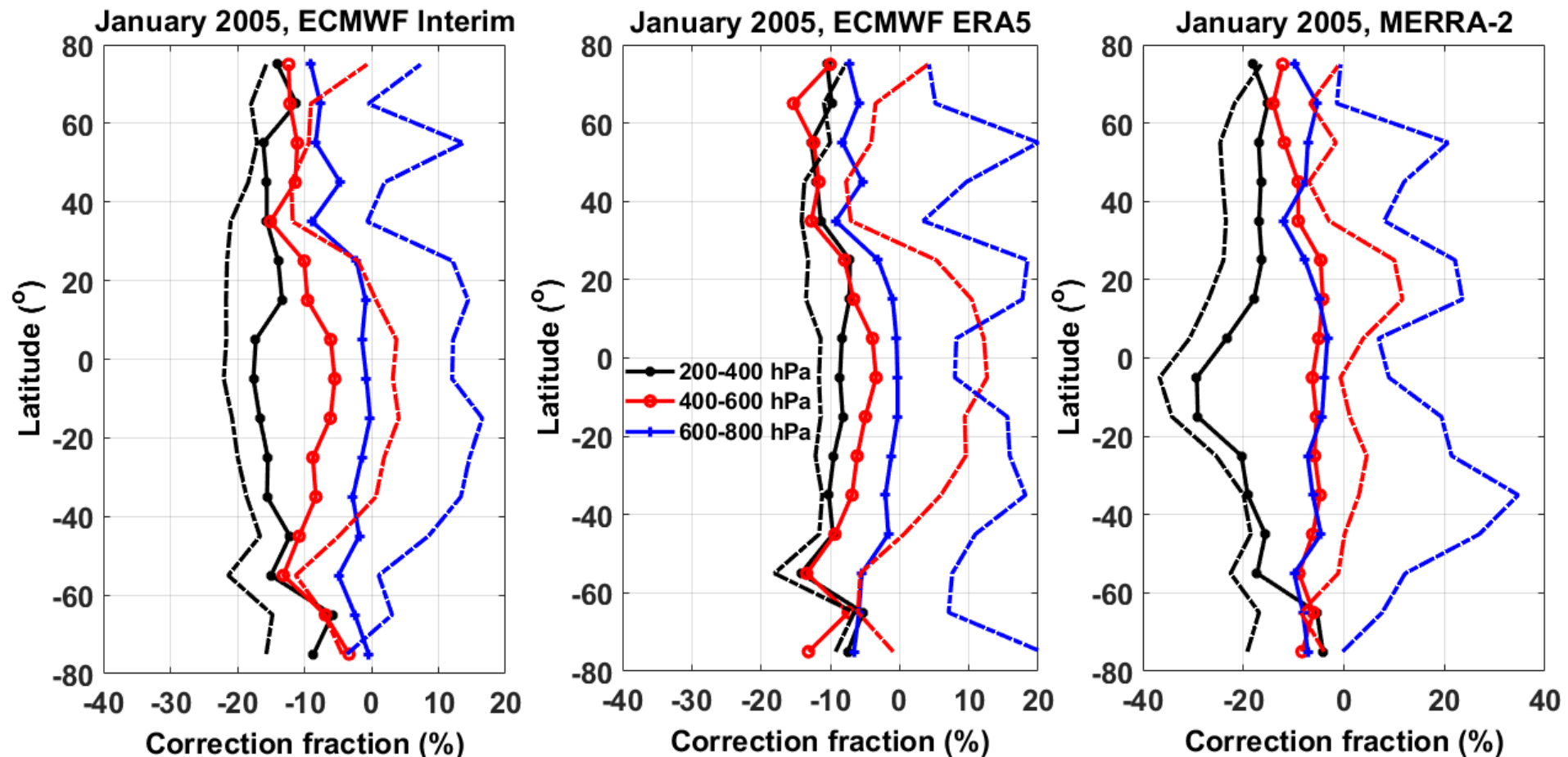
Little biases in T(p) for all reanalyses



Correction fraction is obtained by directly comparing reanalysis with AIRS L-2 profiles
 $(T_{\text{AIRS}}/T_{\text{reanalysis}} - 1) \times 100\%$



Zonal-mean correction fraction for water vapor profiles



AIRS L2 estimated in Chen et al. (2018)

Solid line: grid-search result
(AIRS L1 - Reanalysis)/Reanalysis

Dashed line:
(AIRS L2 - Reanalysis)/Reanalysis

Biases in AIRS L2 (36°N)	Water vapor	Temperature
200-400 hPa	-8.85%	-4.1e-3%
400-600 hPa	4.29%	7.8e-4%
600-800 hPa	4.30%	0.02%



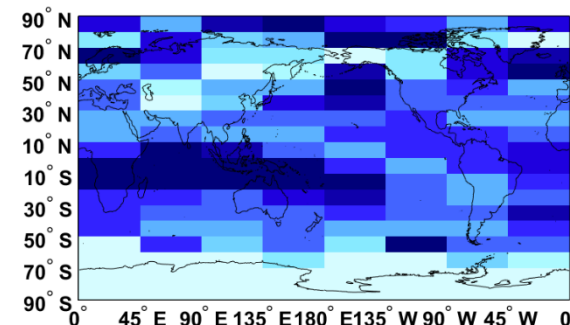
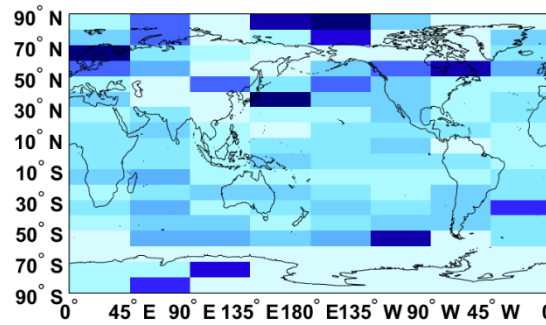
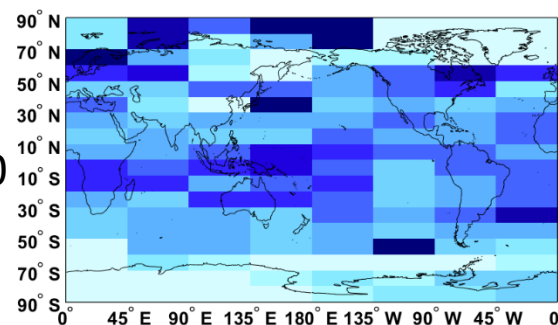
Correction fraction (%) for water vapor profiles

Interim, Jan. 2005

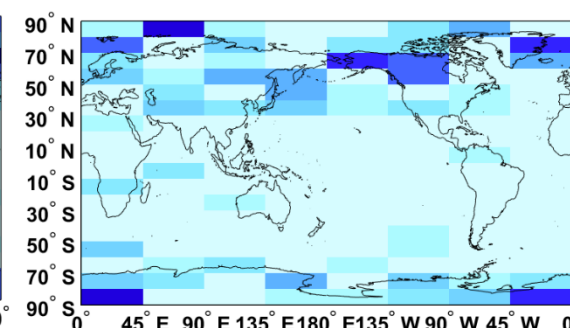
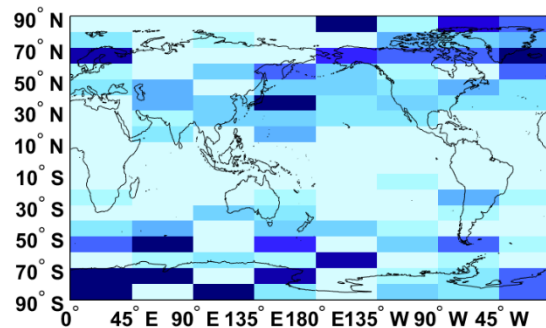
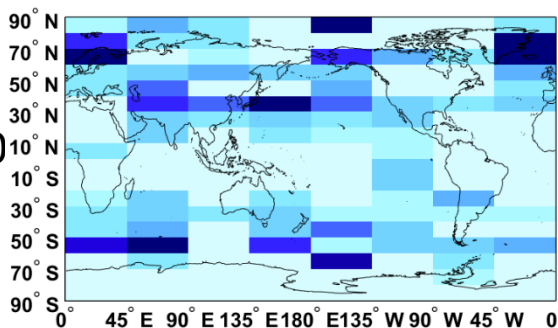
ERA5, Jan. 2005

MERRA-2, Jan. 2005

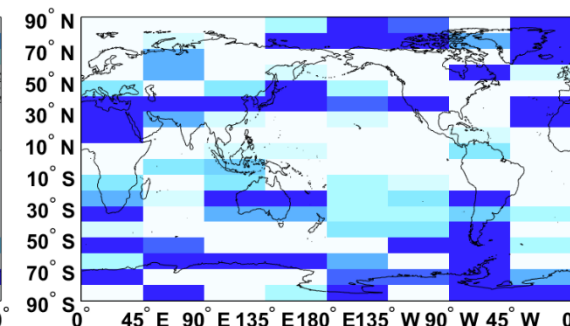
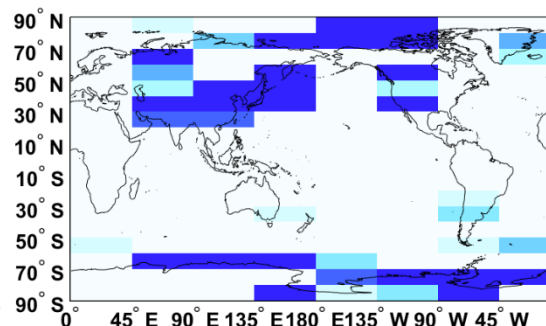
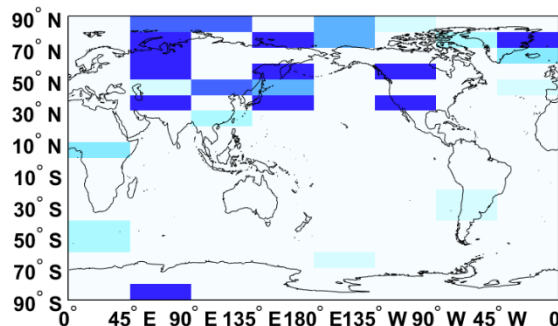
200-400
hPa



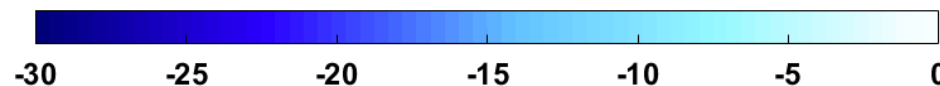
400-600
hPa



600-800
hPa

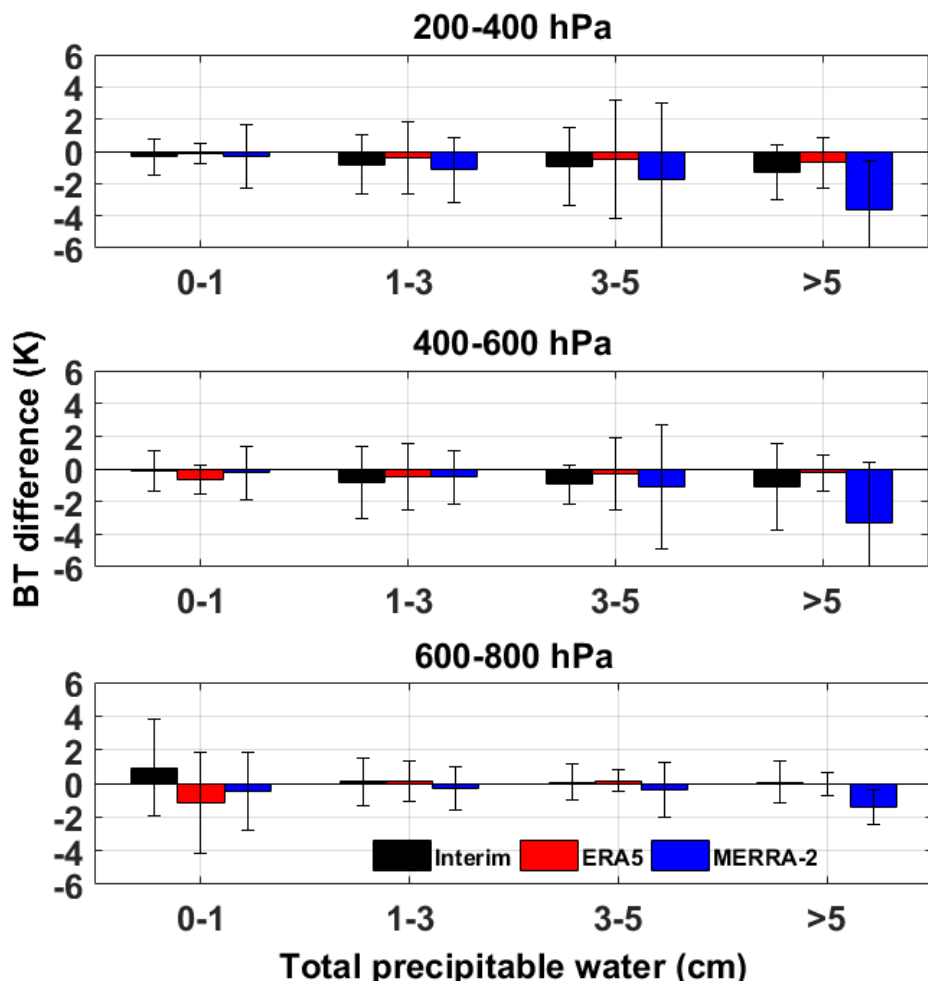


10°-by-45° grid

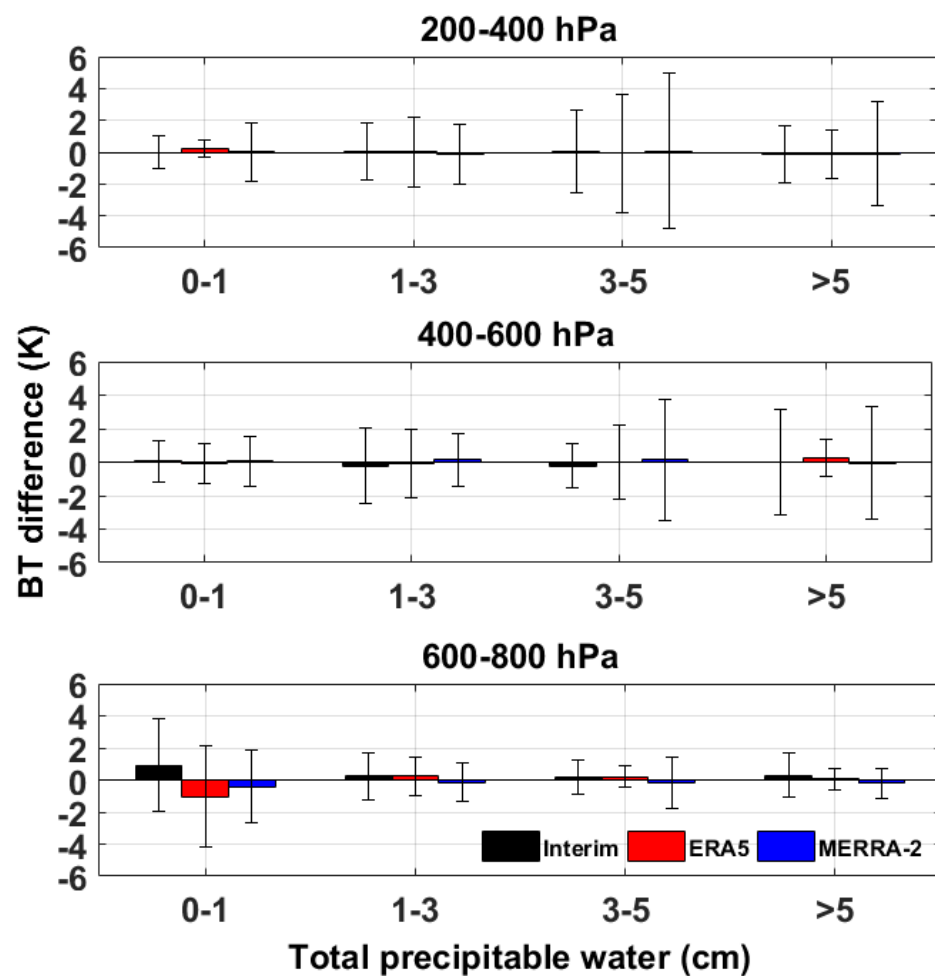


RH-sensitive channels: BT difference w.r.t. TPW (Jan 2005)

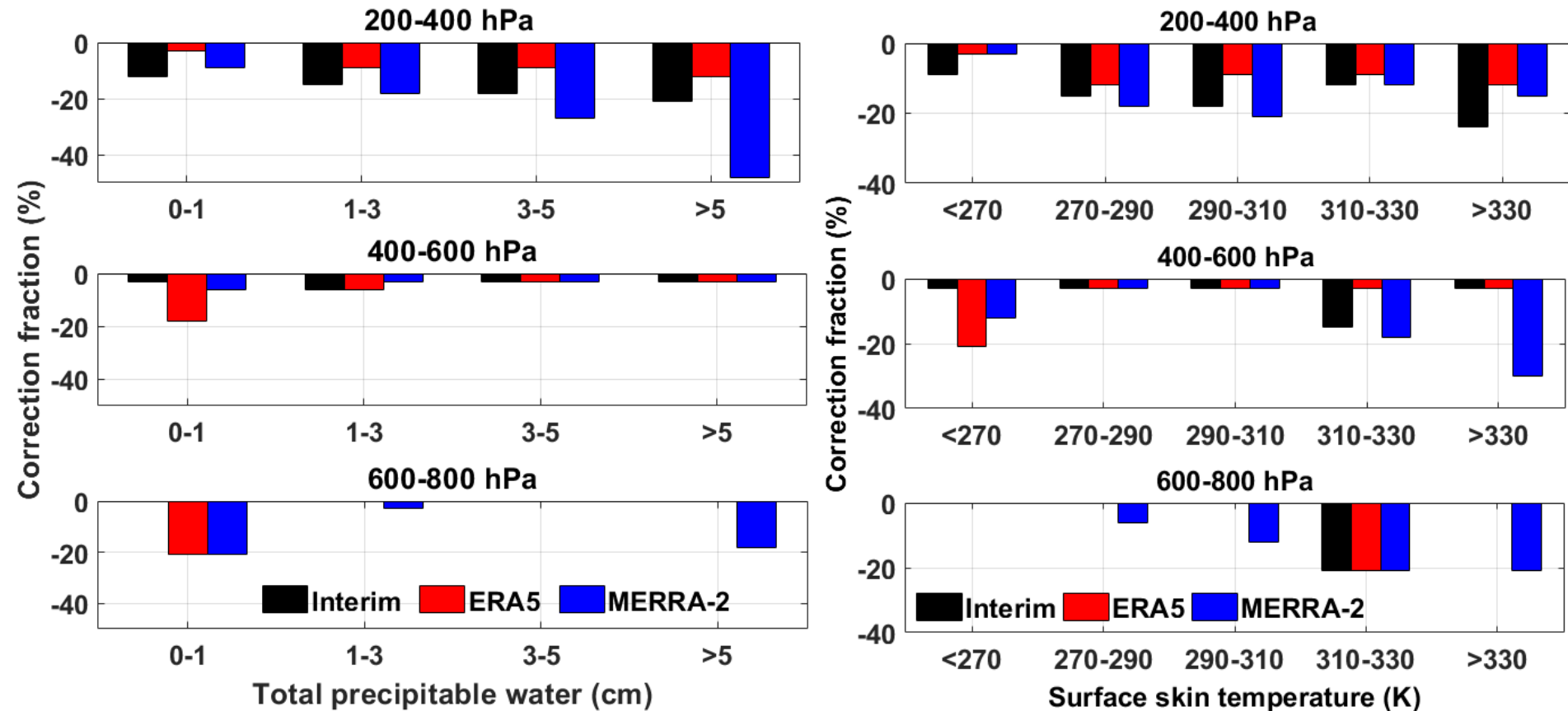
Before correction



After correction



Correction fraction w.r.t. TPW and Ts (90S-90N; Jan 2005)



Difference reanalyses exhibit different dependences with TPW/Ts

Long-term consistency between AIRS and CERES FM3 radiances

Assessing Stability of CERES-FM3 Daytime Longwave Unfiltered Radiance with AIRS Radiances

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Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, Ann Arbor, Michigan

NORMAN G. LOEB

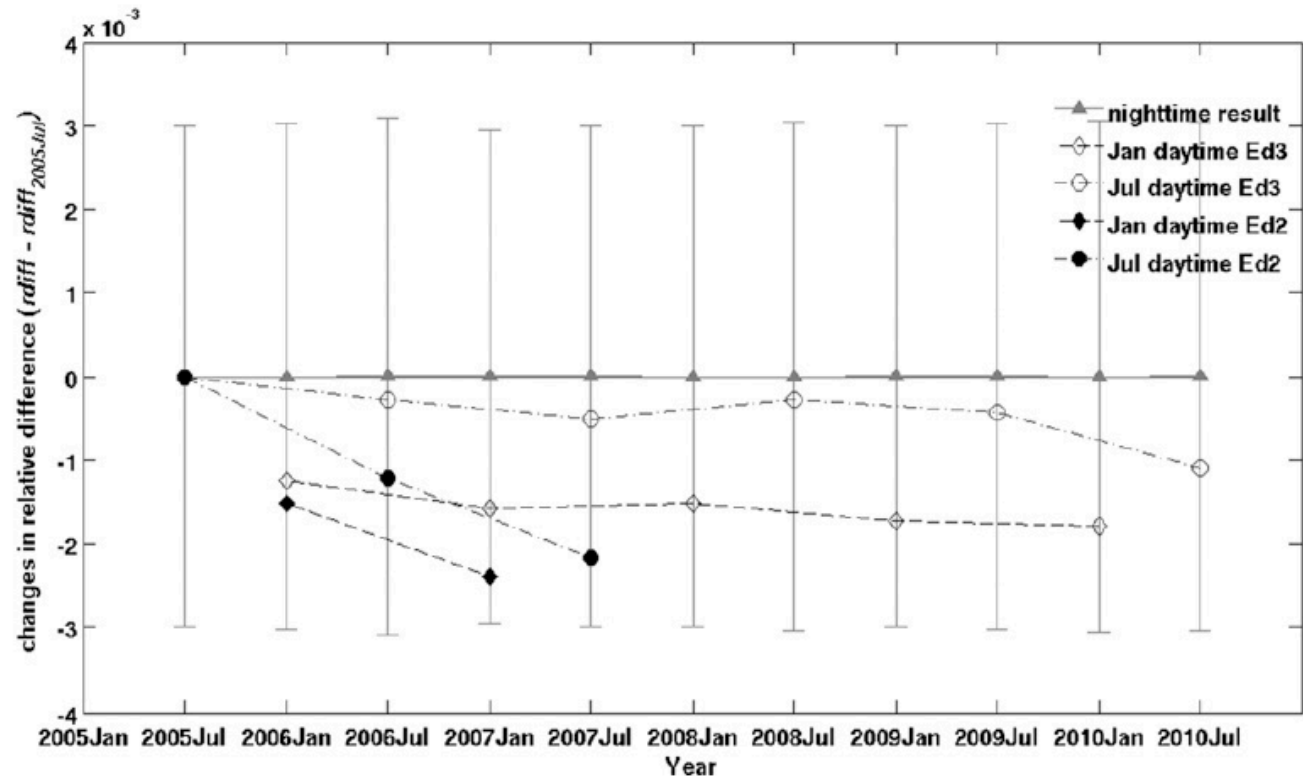
Radiation and Climate Branch, NASA Langley Research Center, Hampton, Virginia

HUIWEN CHUANG

Department of Atmospheric, Oceanic, and Space Sciences, University of Michigan, Ann Arbor, Michigan

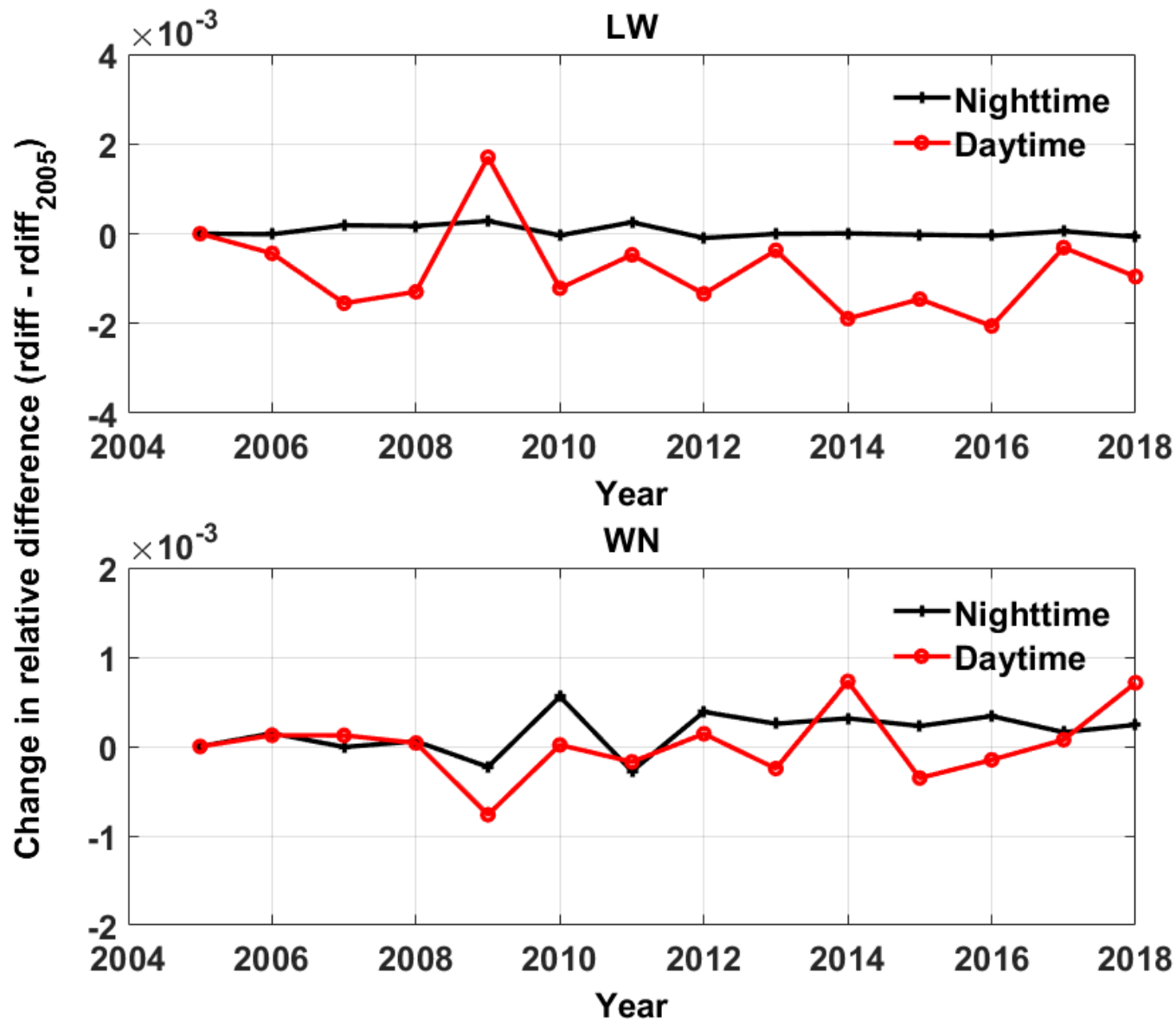
$$\text{rdiff} = \frac{I_{\text{LW_CERES}} - I_{\text{est}}}{I_{\text{est}}}$$

Premise: if no long-term drift in daytime, **rdiff** should remain the same over the years





r_{diff} in Julies w.r.t. r_{diff} of July 2005 (FM3 Ed4)

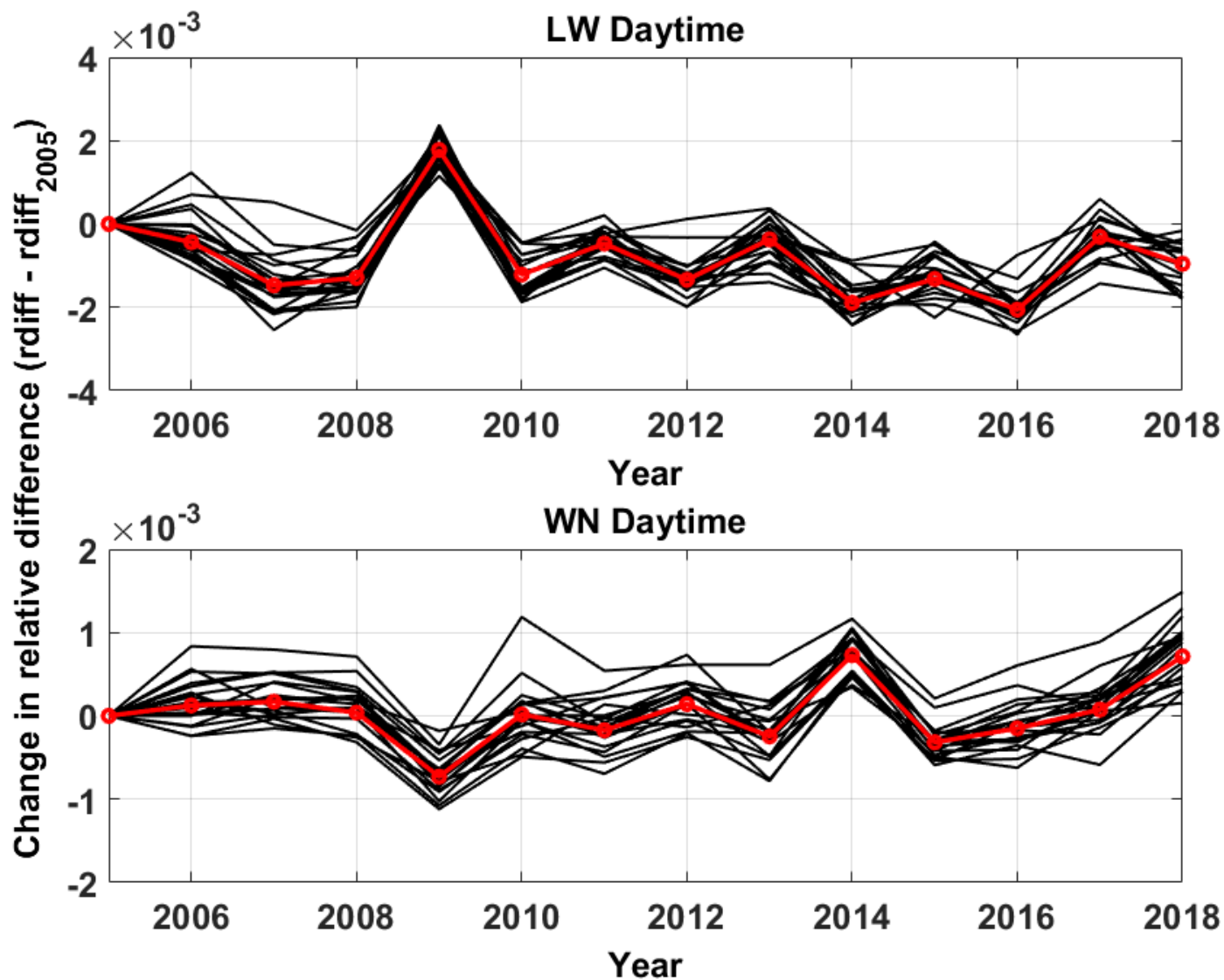


Still, clear-sky VZA 5° only



Sampling uncertainty:

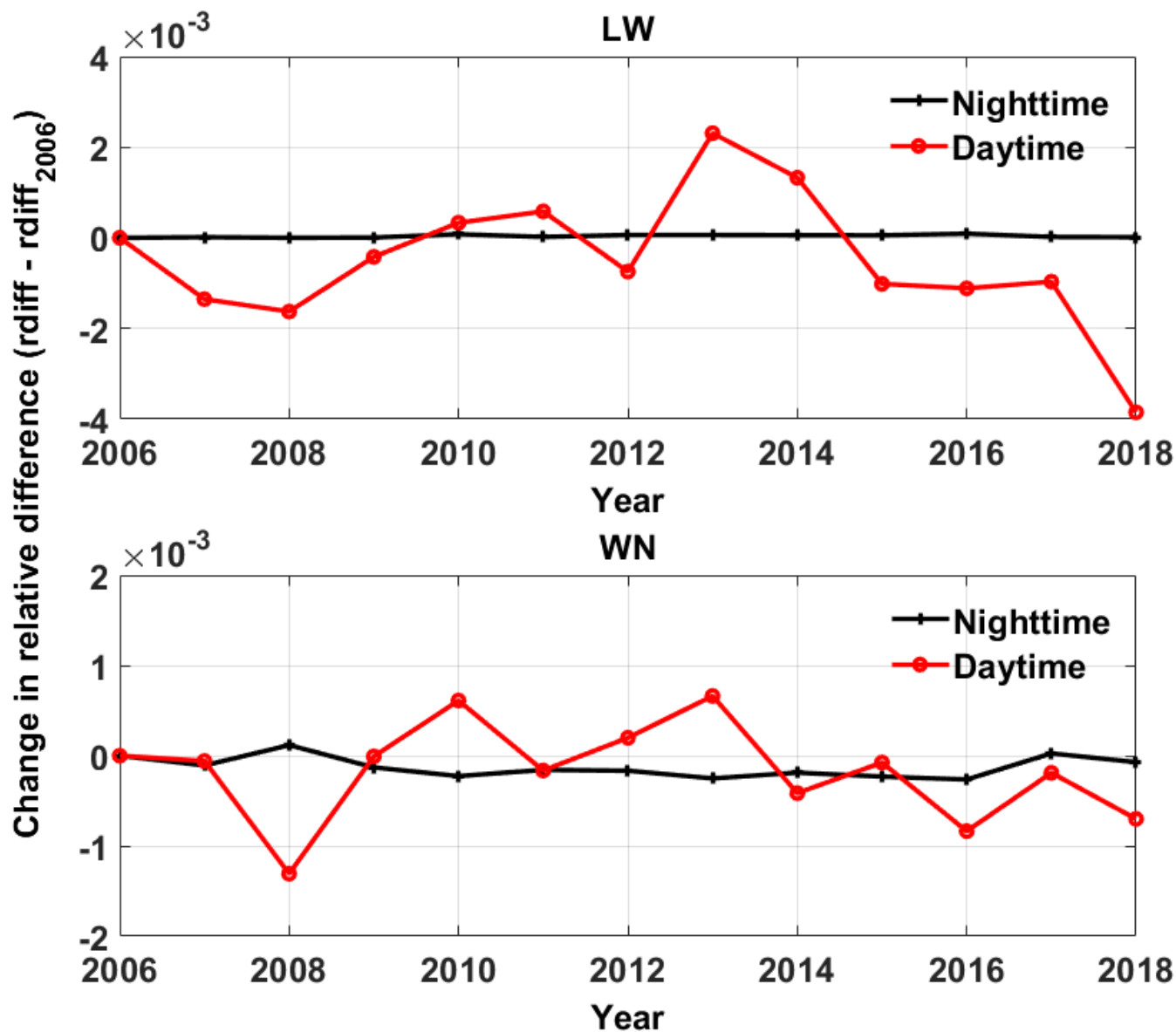
For all Julies, randomly form 20 subsets, each of which includes 13~20 days of data. Then recompute **daytime rdiff** for CERES FM3 Ed4.



Red line is obtained using all data.



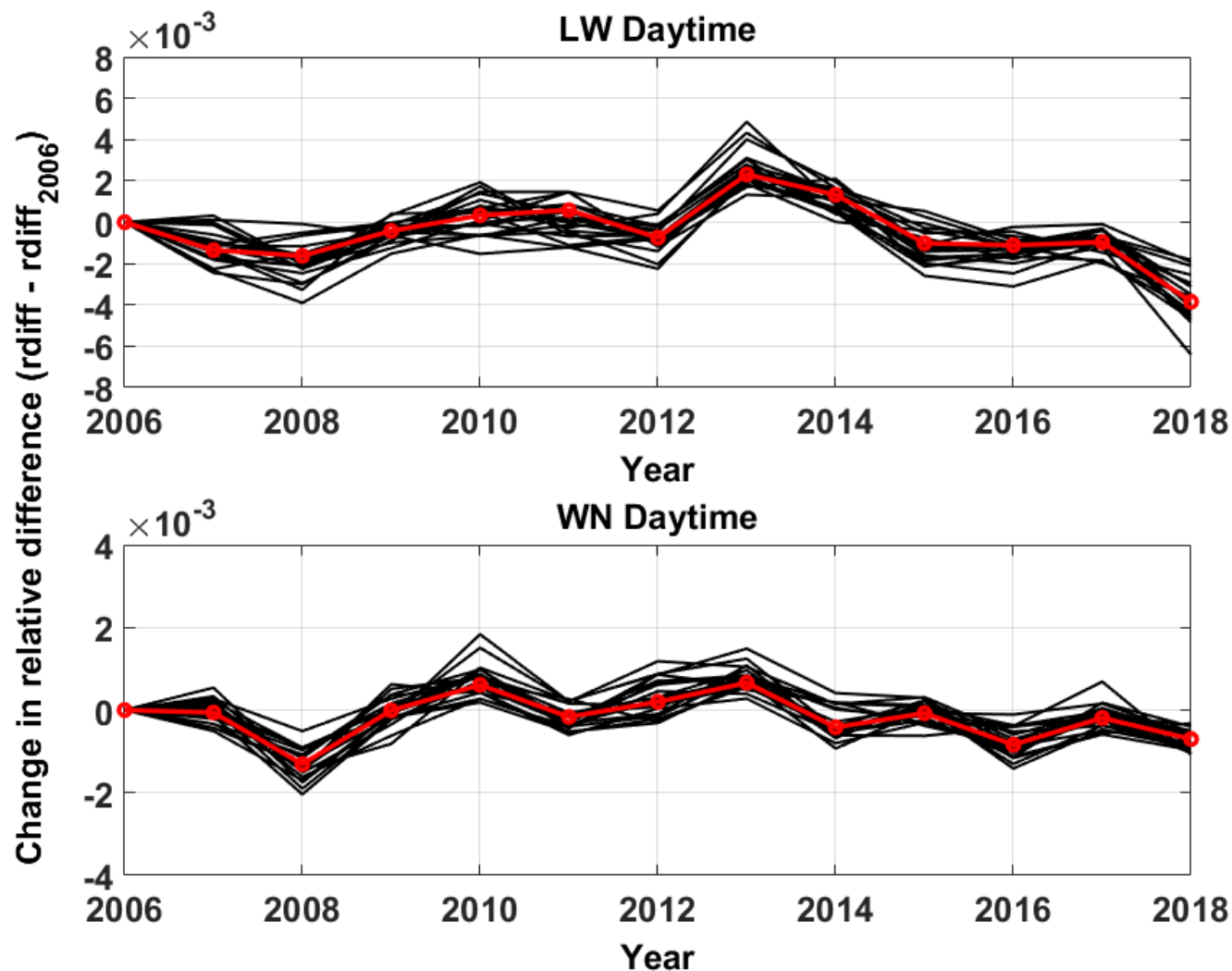
r_{diff} in Januaries w.r.t. r_{diff} of Jan 2006 (FM3 Ed4)





Sampling uncertainty:

For all Januaries, randomly form 20 subsets, each of which includes 13~20 days of data. Then recompute **daytime rdiff** for CERES FM3 Ed4.



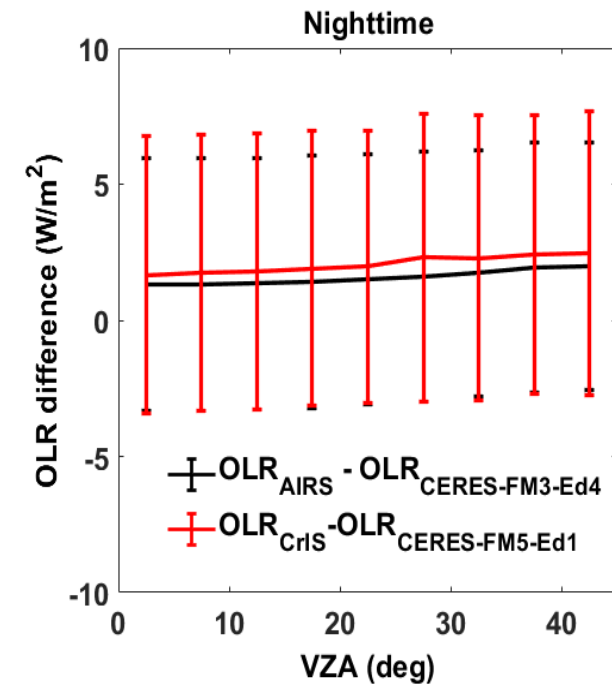
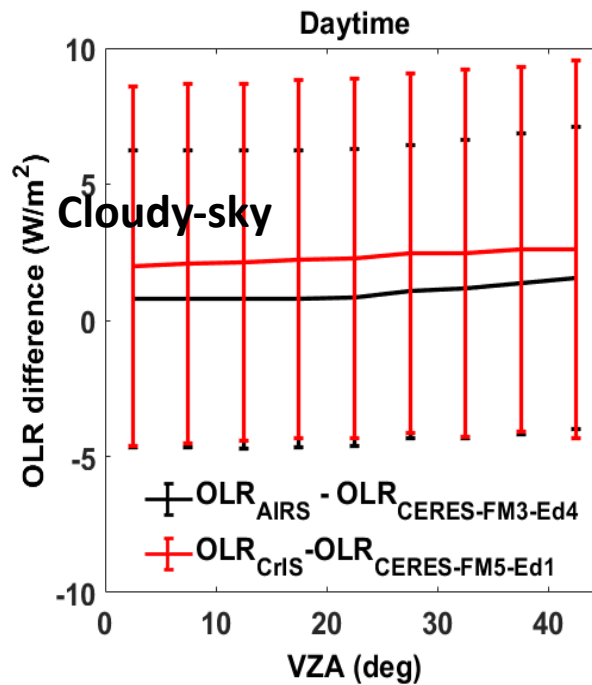
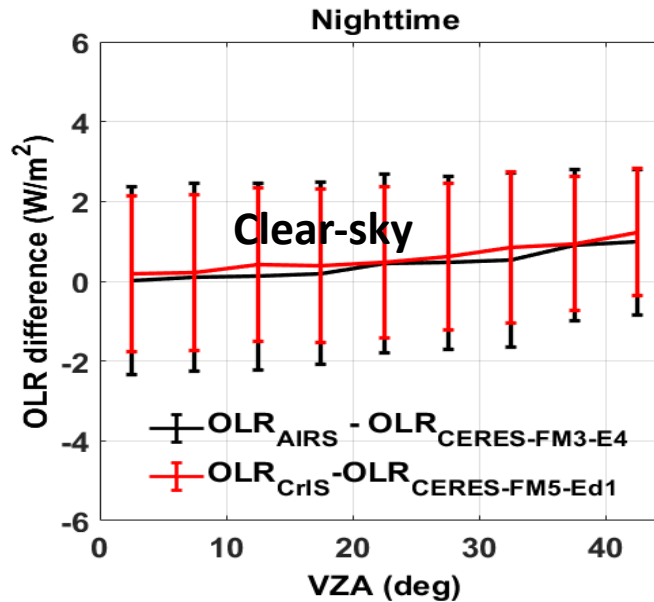
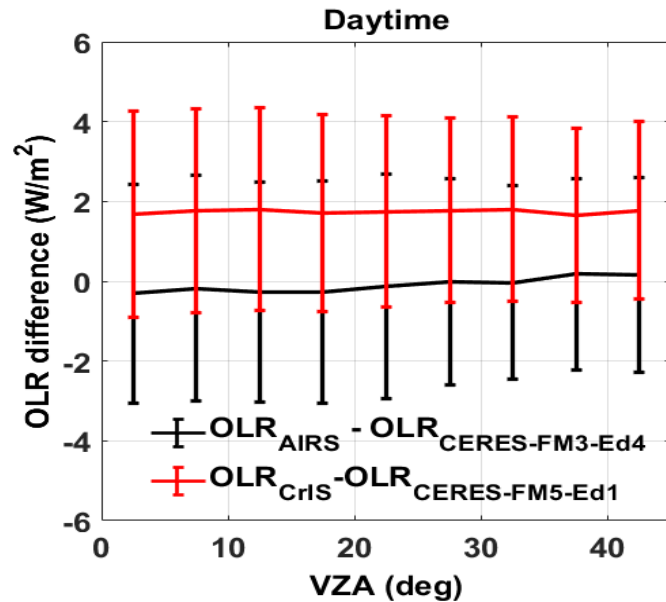
Red line is obtained using all data.



Paths forward

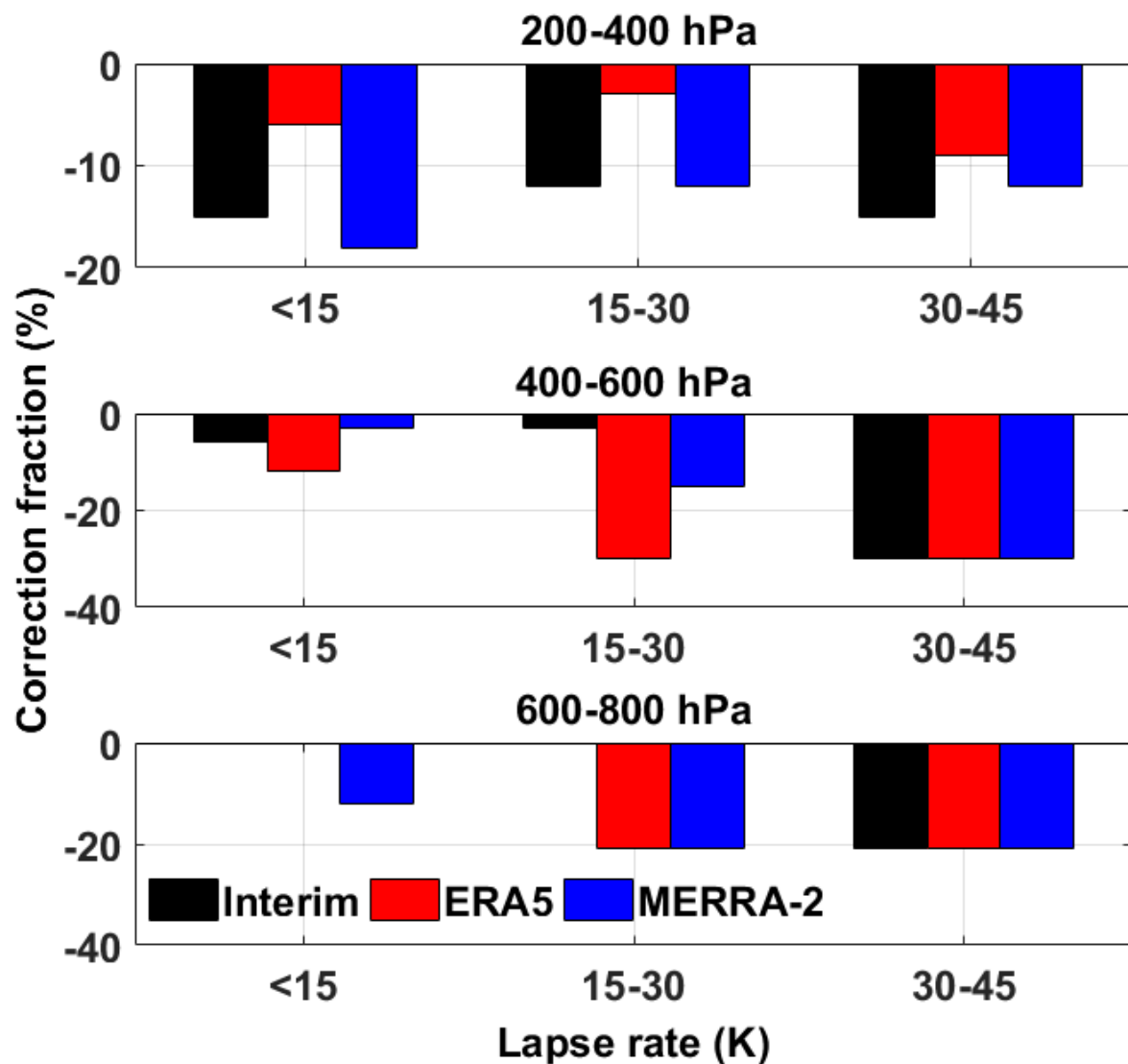
- The moist bias estimate
 - Extend to other months
 - Can be applied to GEOS5 FP/FPIT as well
 - Can use to check the bias adjustments used in SARB group
- The long-term radiance consistency check
 - Extend to all-sky radiances
 - Apply to CrIS/FM5

Extend spectral OLR dataset to S-NPP



Thank You!

Correction fraction w.r.t. lapse rate (90S-90N; Jan 2005)

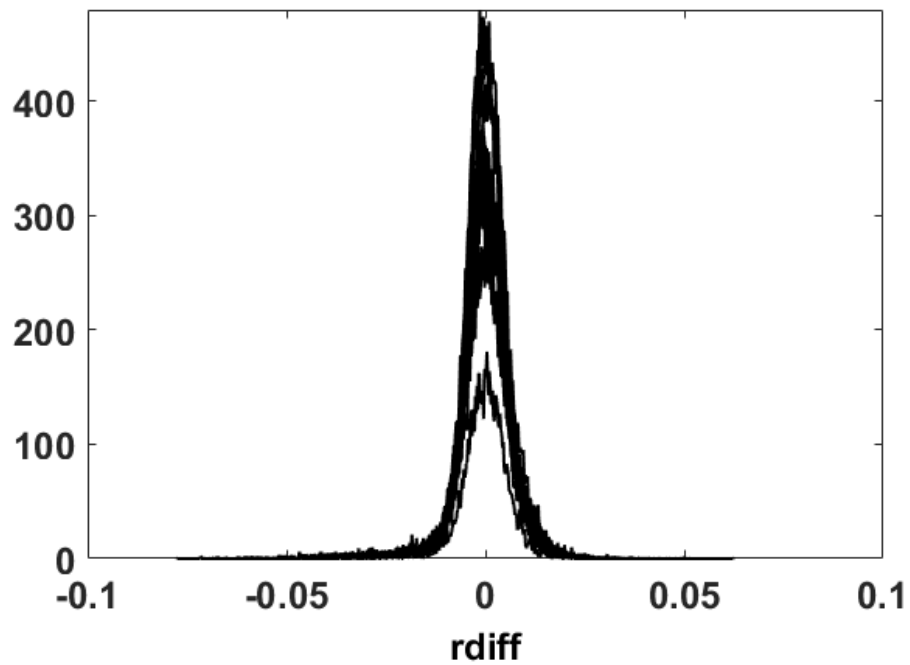


Lapse rates are from reanalyses themselves.

The PDF of r_{diff} for LW radiance

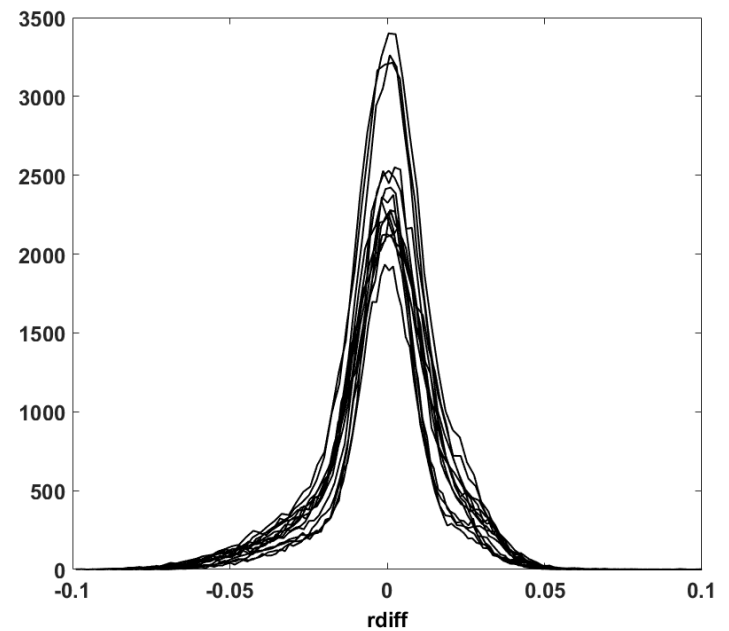
$$r_{\text{diff}} = \frac{I_{\text{LW_CERES}} - I_{\text{est}}}{I_{\text{est}}}$$

Januaries



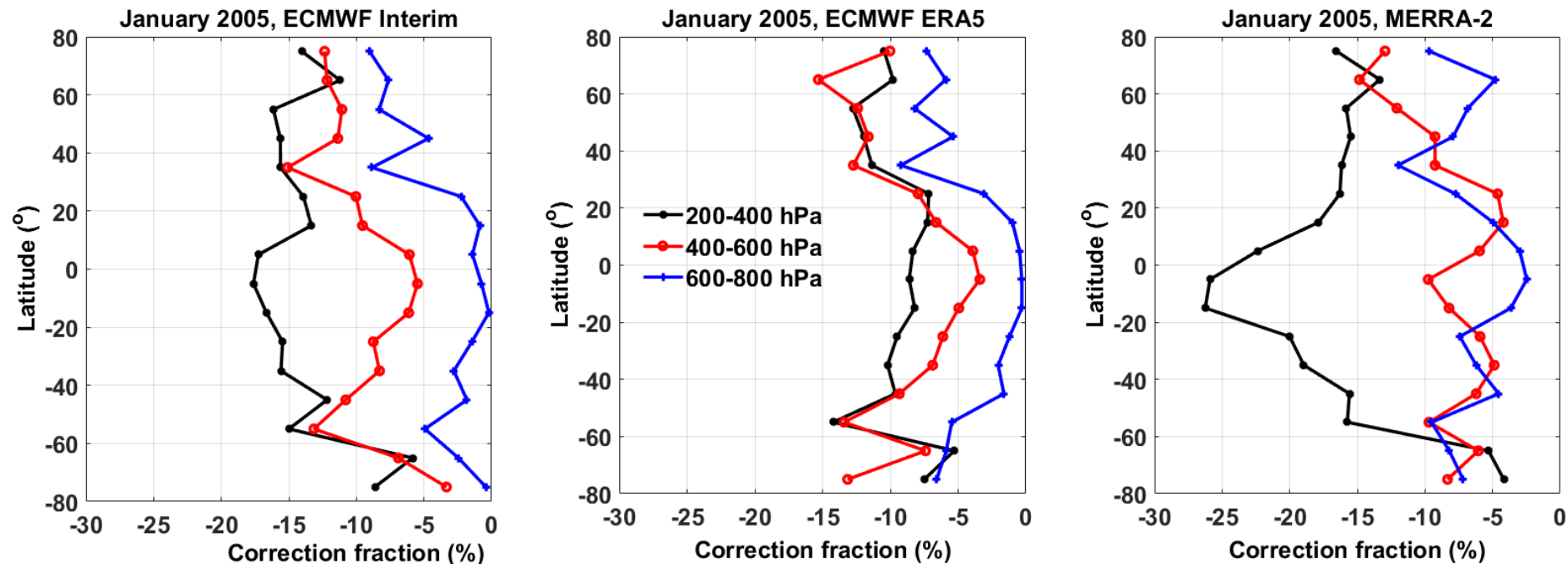
All R-squares are >0.999.

Julies



All R-squares are >0.999.

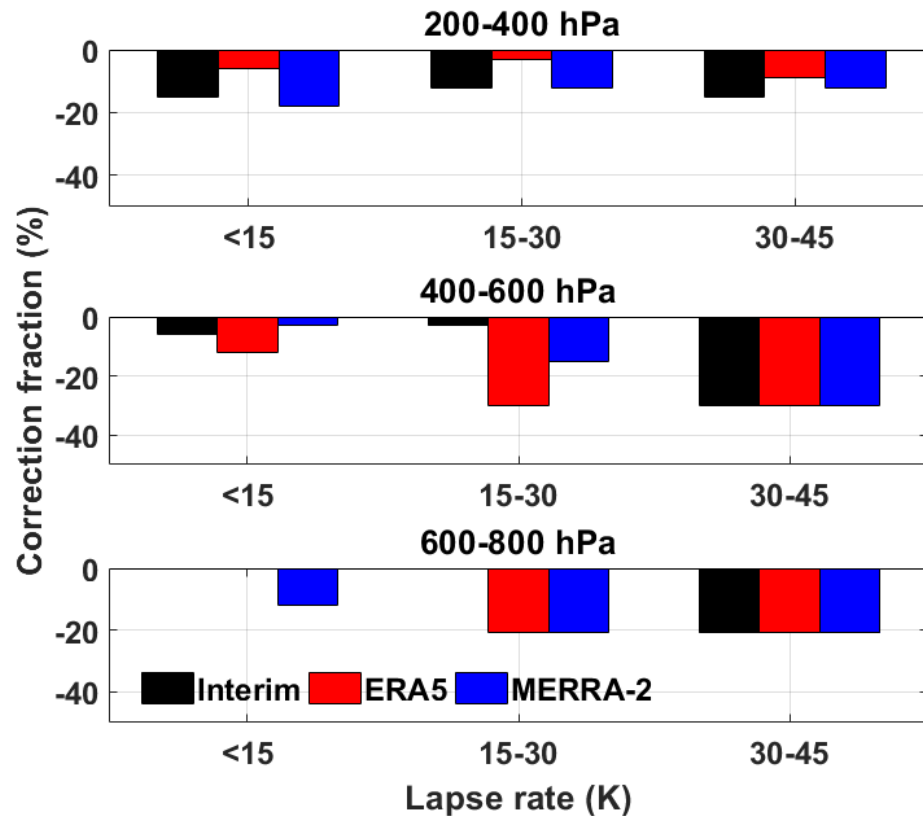
Zonal-mean correction fraction for water vapor profiles in ECMWF interim, ERA5, and MERRA-2



10-latitude bands

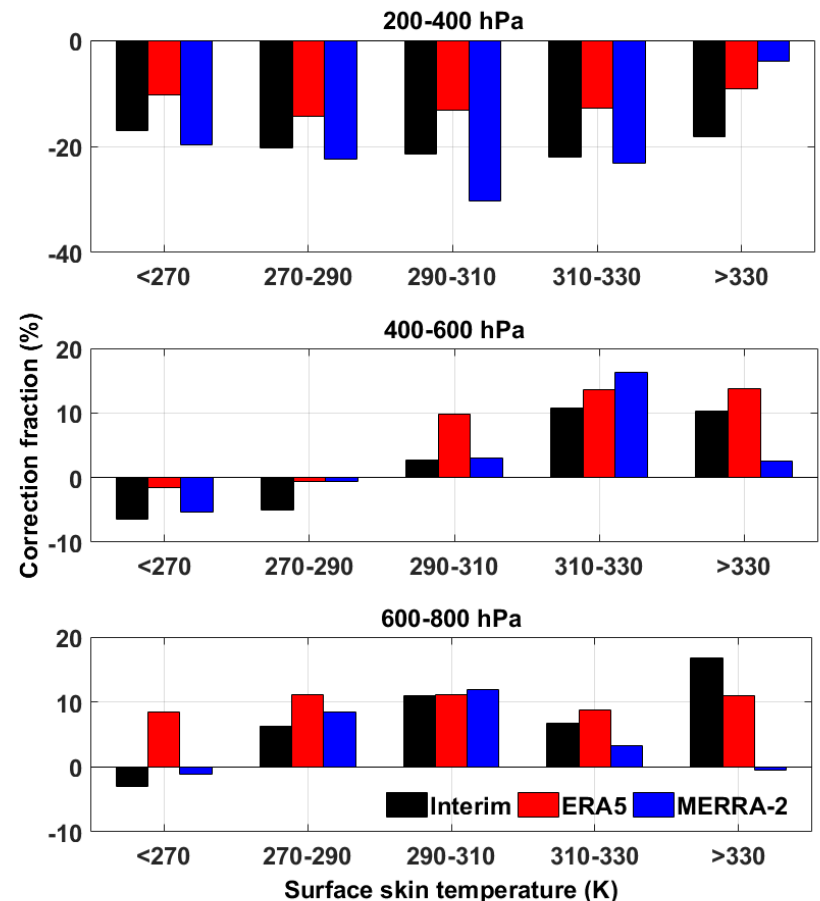
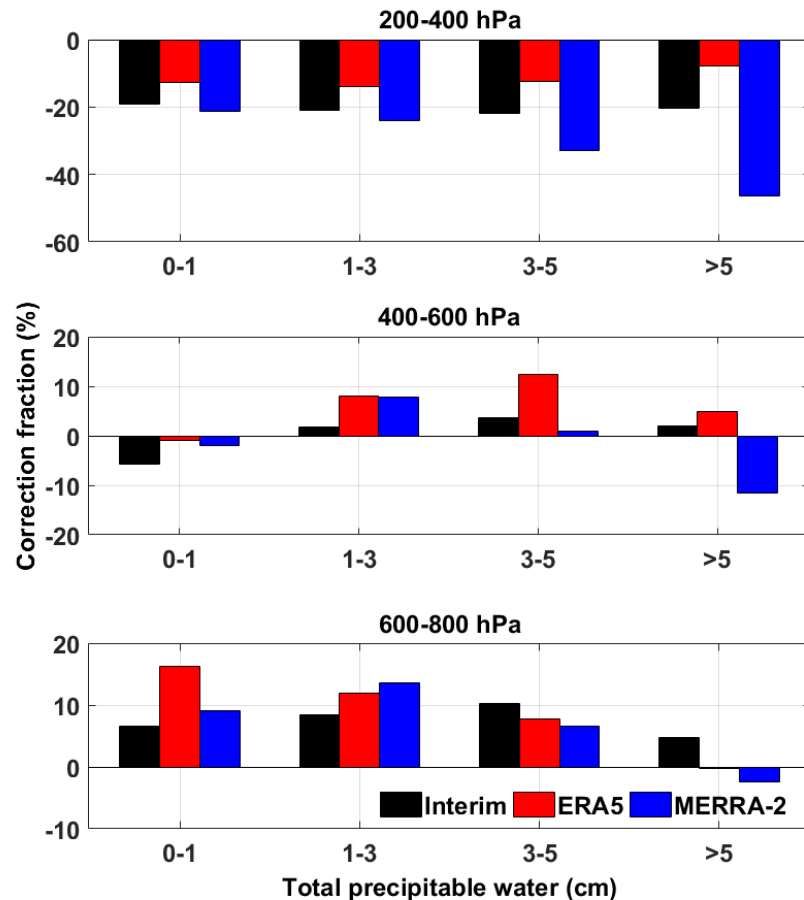
Correction fraction W.R.T. lapse rate (90S-90N; Jan 2005)

Adjust water vapor profiles only



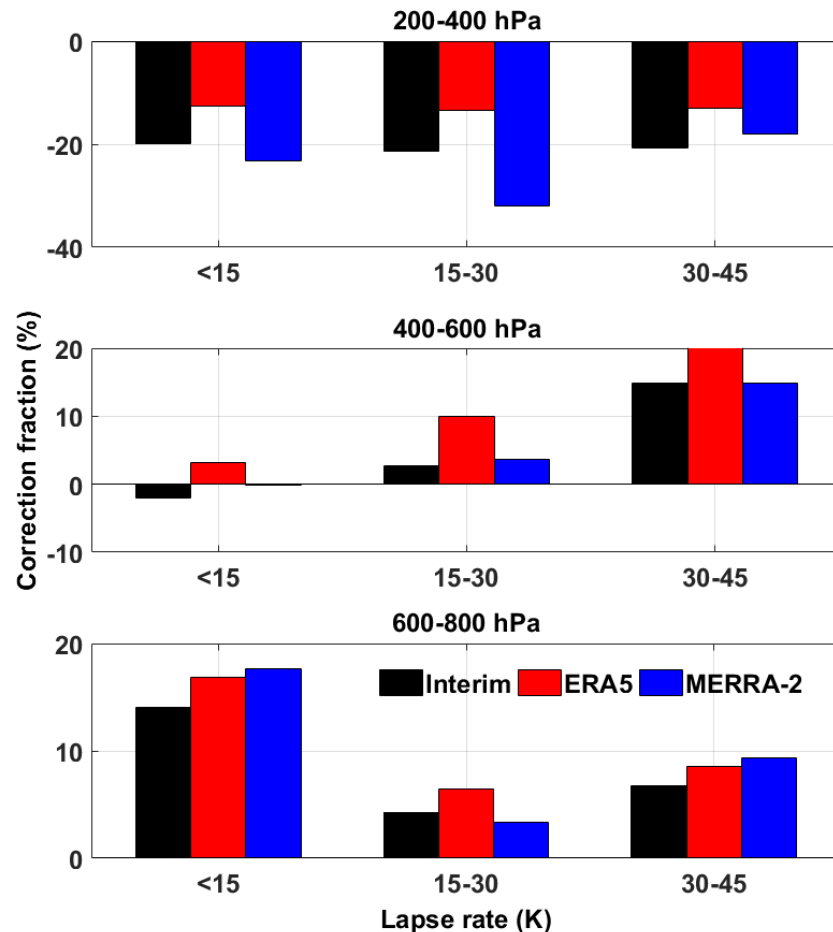
Lapse rates are from reanalyses themselves.

Correction fraction for q W.R.T. TPW and Ts (90S-90N; Jan 2005)



Correction fraction is obtained by directly comparing reanalysis with AIRS L-2 profiles
 $(q_{\text{AIRS-L2}}/q_{\text{reanalysis}} - 1) \times 100\%$

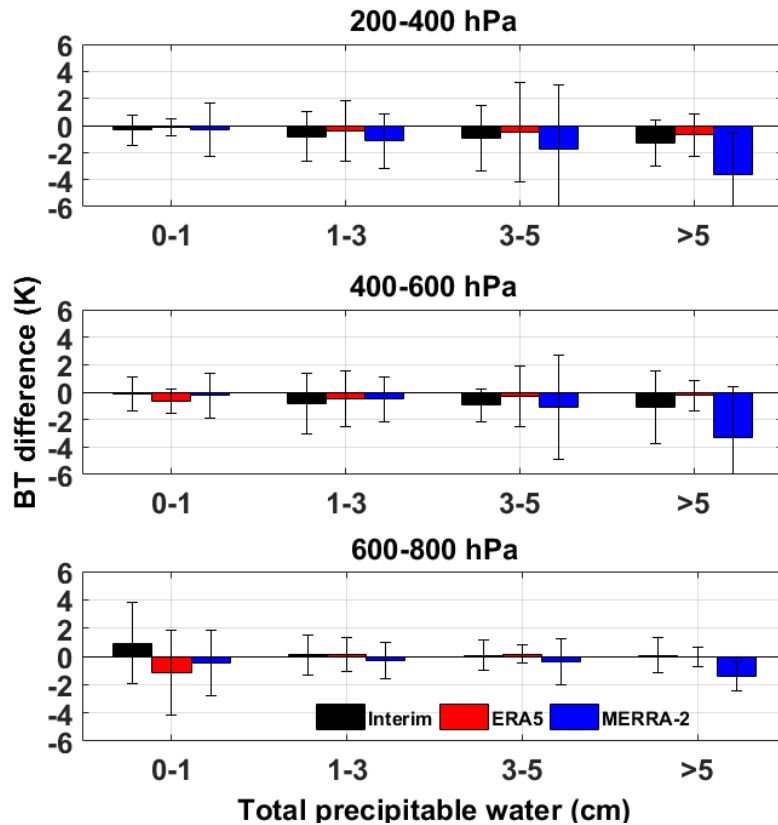
Correction fraction for q W.R.T. lapse rate(90S-90N; Jan 2005)



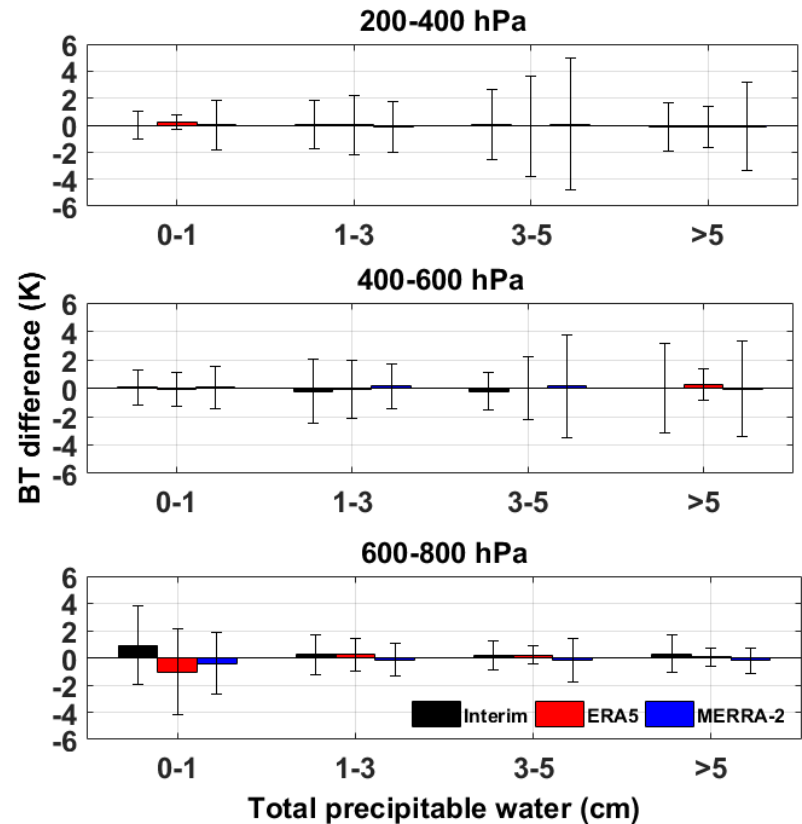
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RH-sensitive BT difference W.R.T. TPW (Jan 2005)

Before correction

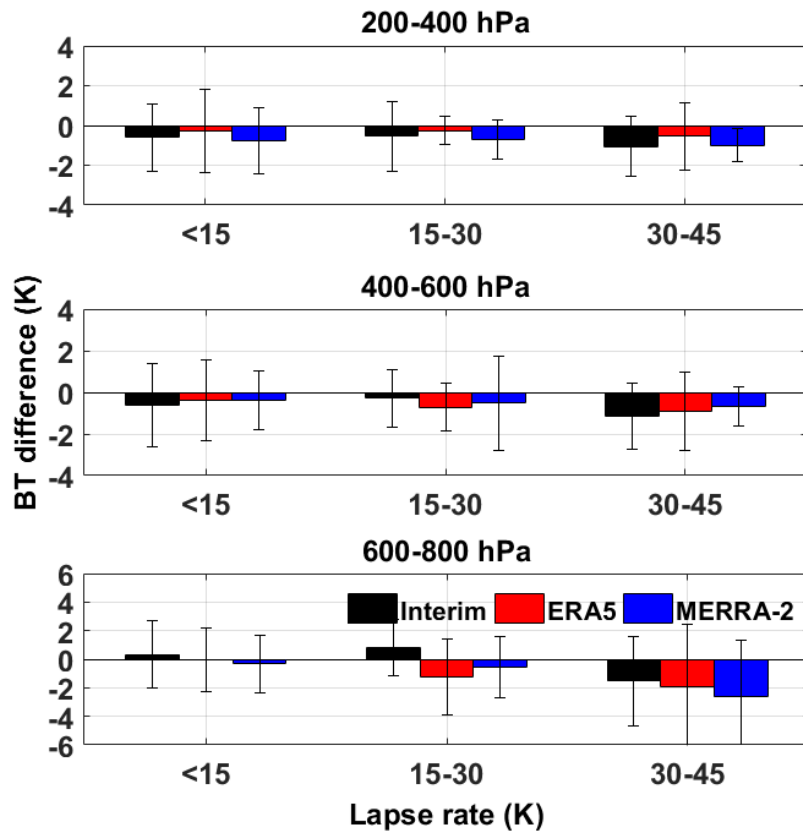


After correction

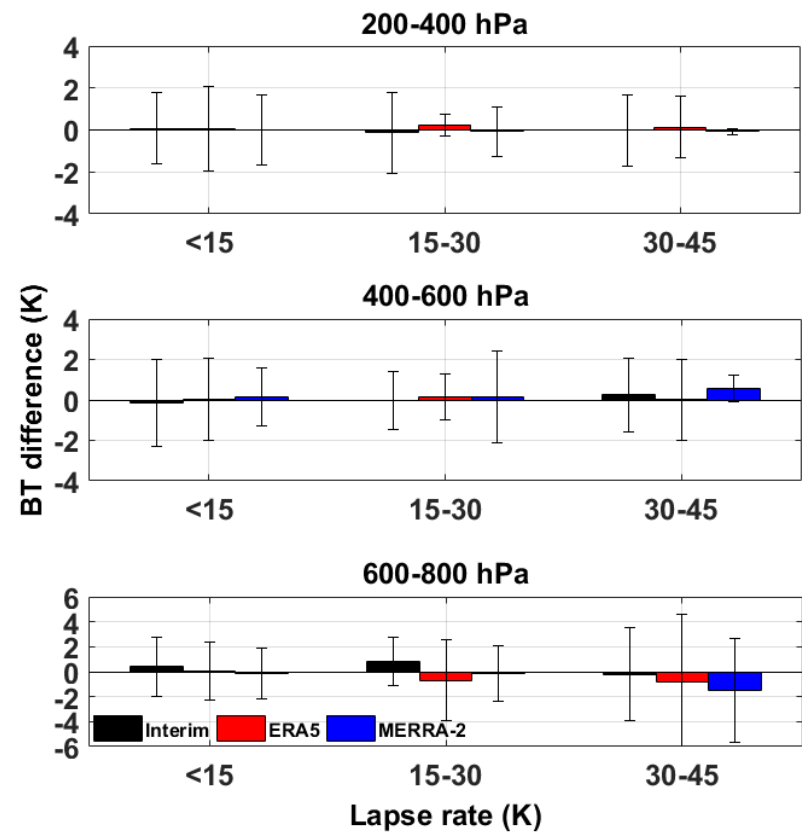


RH-sensitive BT difference W.R.T. lapse rate (Jan 2005)

Before correction

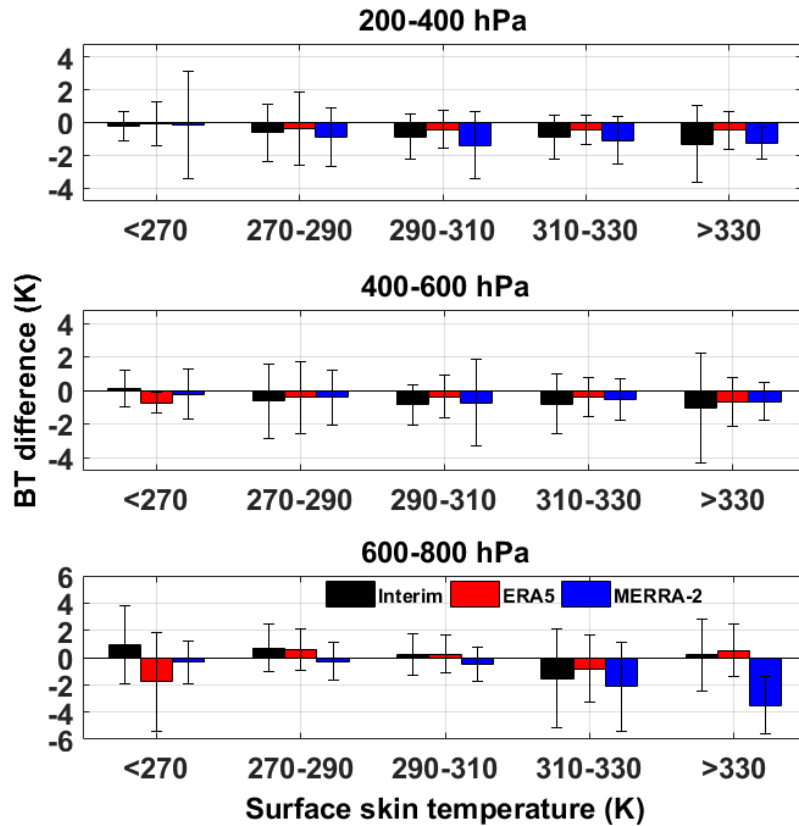


After correction

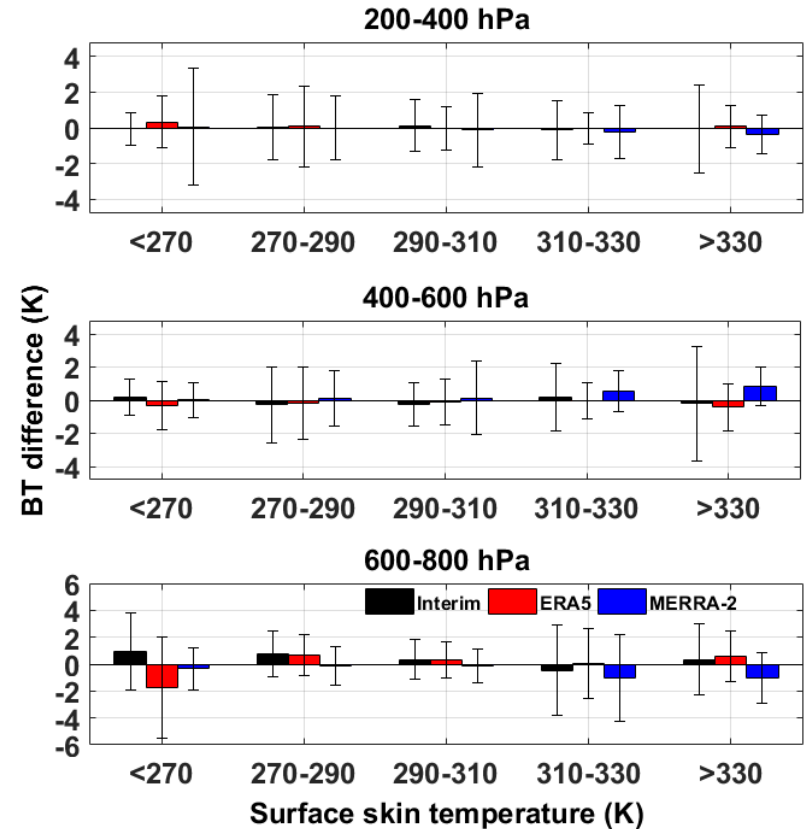


RH-sensitive BT difference W.R.T. TS (Jan 2005)

Before correction

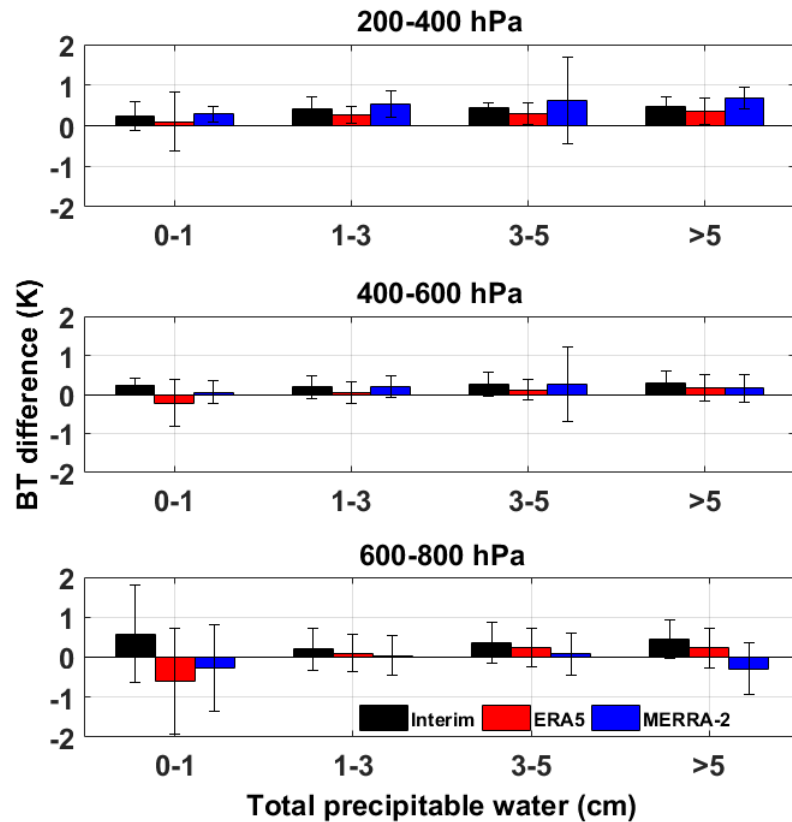


After correction

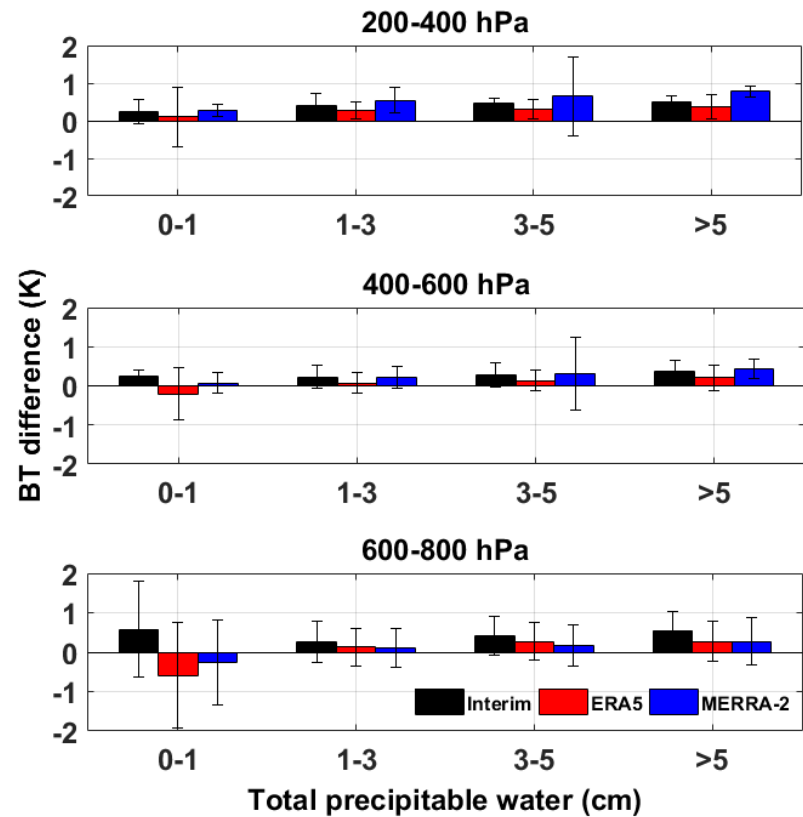


T-sensitive BT difference W.R.T. TPW (Jan 2005)

Before correction

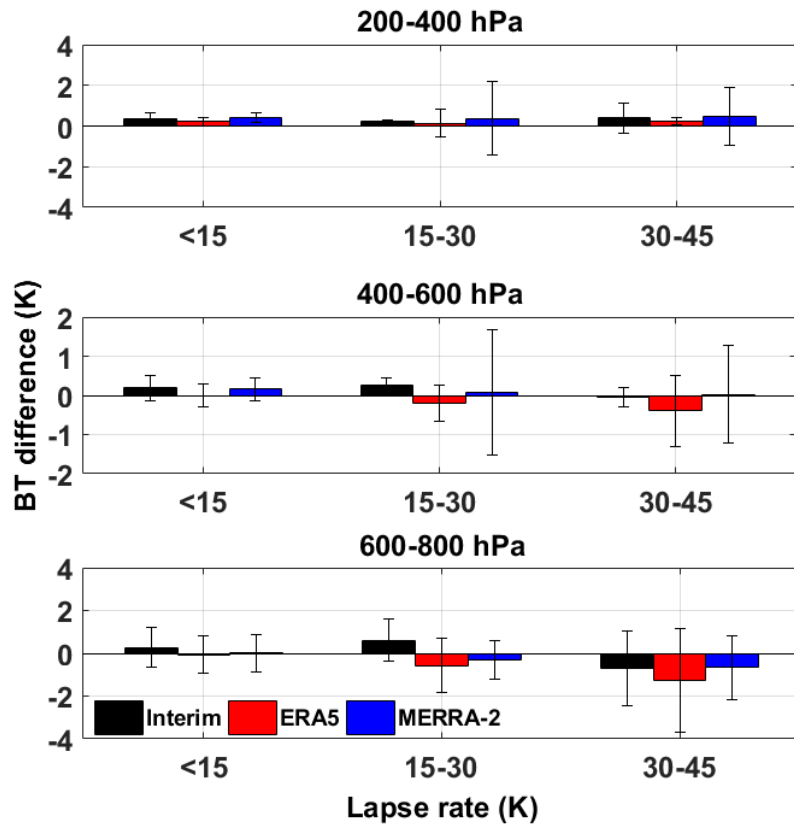


After correction

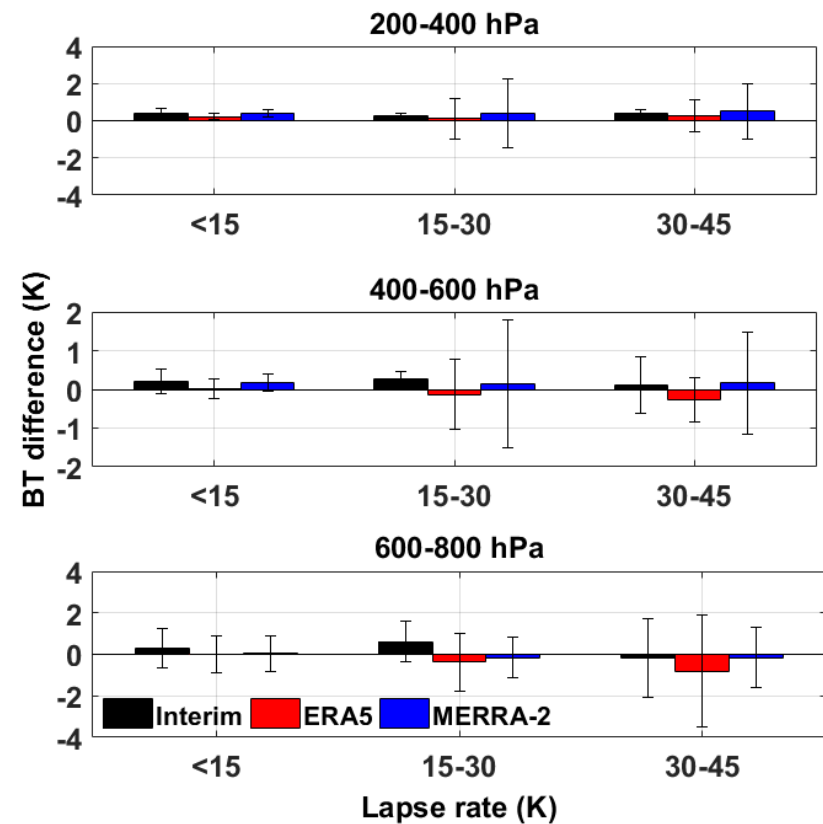


T-sensitive BT difference W.R.T. lapse rate (Jan 2005)

Before correction

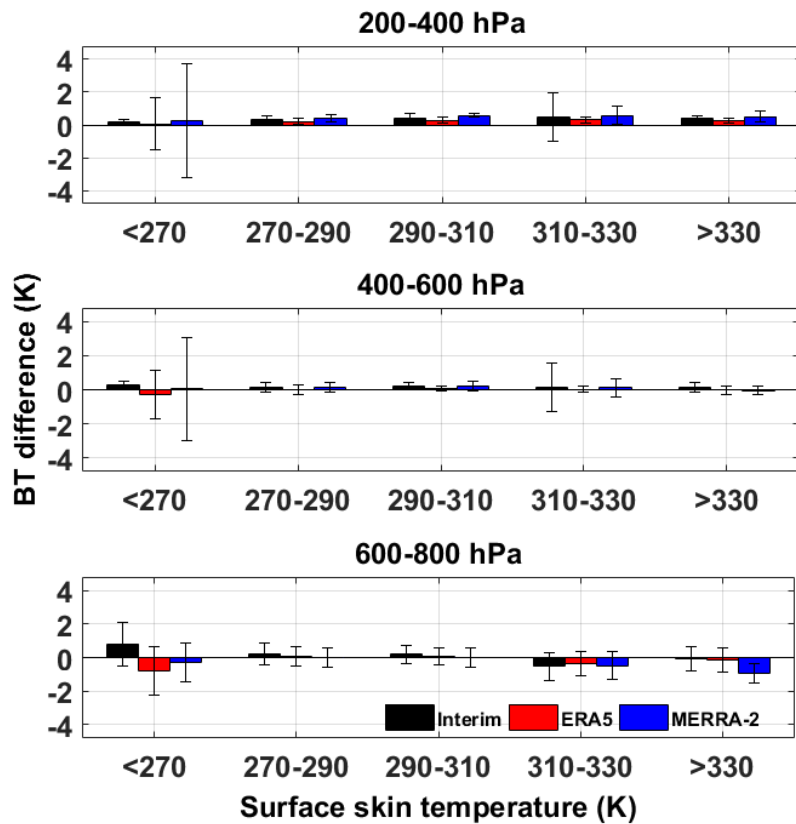


After correction



T-sensitive BT difference W.R.T. TS (Jan 2005)

Before correction



After correction

